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CONTENTS AND INDEX.

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CONTENTS.

VOL. XXXII, January–June, 1904.

For alphabetical index, see page v.

No. 1. JANUARY.

PAGE

Ferroinclave: A Fireproof Building Material. *H. F. Cobb* 1
Proposed Improvements in St. Louis Terminals. *A. P. Greensfelder* .. 11
Association of Engineering Societies 29

Proceedings of Societies.

Lists of Members of the Associated Societies.

No. 2. FEBRUARY.

Timber Crib Foundations. *George B. Francis* 65
Discussion. *J. W. Rollins, Jr.* 74
The Place of the Great Raised Beaches in Geology. *Herbert W. Pearson* 78
Obituary—
William C. Ogden........ 91
Frank Prescott Johnson........ 92

Proceedings of Societies.

No. 3. MARCH.

The Reconstruction of Foundations for the Hotel Wollaton, Brookline, Mass. *Dana M. Pratt* 95
Discussion. *Henry F. Bryant* 110
Construction of a Scherzer Double-Roller Lift Bridge at Middle Seneca Street, Cleveland, Ohio. *William J. Carter* 113
The Lackawanna and Wyoming Valley Railroad. *George B. Francis* .. 118
The Value of Inspection of Metal Bridges During Construction and Erection. *Walter L. Golden* 130

Proceedings of Societies.

No. 4. APRIL.

Argentine: Past, Present, Future. *E. L. Corthell* 149
Rice in Texas and Louisiana. *Francis M. Henry* 178
Theater Construction which Insures Public Safety. *E. O. Fallis* 189
Origin of the United States Land Surveys. *W. A. Truesdell* 194
Address. *George T. Wickes* 202

Proceedings of Societies.

No. 5. MAY.

PAGE

Sewage Disposal and the Septic Tank. Papers and Discussions by the Boston Society of Civil Engineers.

A Description of Sewage Disposal Systems in Massachusetts. *X. Henry Goodnough* 213

Adaptability of the Massachusetts Method of Intermittent Sand Filtration to Sewage Disposal Problems in Other States. *F. Herbert Snow* 225

Discussion. *Messrs. Harrison P. Eddy, Prof. Leonard P. Kinnicutt, Freeman C. Coffin, F. P. Stearns, Geo. A. Carpenter, T. Howard Barnes, Otis F. Clapp* 237

The Use of the Septic Tank in Connection with Sewage Disposal Works. *Frank A. Barbour* 251

Discussion. *Messrs. Harrison P. Eddy, George E. Bolling, Andrew J. Gavett, R. Winthrop Pratt, X. H. Goodnough, Dr. Douglas C. Moriarta, Harry W. Clark, Leonard P. Kinnicutt, C. E. A. Winslow, F. Herbert Snow.*

Proceedings of Societies.

No. 6. JUNE.

Design of the Steel-Concrete Work of the Harvard Stadium. *Lewis J. Johnson* 293

Discussion. *Prof. Chas L. Norton, Gaetano Lanza, Arthur W. French, Geo, F. Swain, W. K. Hatt* 293

Methods for Determining the Equations of Experimental Curves. *A. S. Langsdorf* 325

The Utilization of Niagara Power. *H. W. Buck* 344

Progress in Railroad Bridge Building. *F. C. McMath* 352

Proceedings of Societies.

INDEX.

VOL. XXXII, January–June, 1904.

The six numbers were dated as follows:

No. 1, January.	No. 3, March.	No. 5, May.
No. 2, February.	No. 4, April.	No. 6, June.

ABBREVIATIONS.—P = Paper; D = Discussion; I = Illustrated. Names of authors of papers, etc., are printed in *italics*.

PAGE

Adaptability of the Massachusetts Method of Intermittent Sand Filtration to Sewage Disposal Problems in Other States. *F. Herbert Snow*....P., D., I., May, 225
Address. *George T. Wickes*, President, Montana Society of Engineers ....April, 202
Argentine: Past, Present, Future. *Elmer L. Corthell*....P., I., April, 149
Association of Engineering Societies....Jan., 29

Barbour, Frank A. Use of the Septic Tank in Connection with Sewage Disposal Works....P., D., May, 251
Beaches, The Place of the Great Raised——, in Geology. *Herbert W. Pearson* ....P., I., Feb., 78
Bridge, Railroad——, Progress in——, Building. *F. C. McMath.* P., June 352
Bridge, Scherzer Double-Roller Lift——, Construction of a——, at Middle Seneca Street, Cleveland, Ohio. *William J. Carter.* P., I., March, 113
Bridges, Metal——, Value of Inspection of——, During Construction and Erection. *Walter L. Golden*....P., March, 130
Buck, H. W. Utilization of Niagara Power....P., I., June, 344
Building Material, A Fireproof——. Ferroinclave. *H. F. Cobb.* P., I., Jan., 1

Carter, William J. Construction of a Scherzer Double-Roller Lift Bridge at Middle Seneca Street, Cleveland, Ohio....P., I., March 113
Cobb, H. F. Ferroinclave: A Fireproof Building Material. P., I., Jan., 1
Construction of a Scherzer Double-Roller Lift Bridge at Middle Seneca Street, Cleveland, Ohio. *William J. Carter*....P., I., March 113

PAGE

Corthell, Elmer L. Argentine; Past, Present, Future.....P., I., April, 149
Crib, Timber——, Foundations. *Geo. B. Francis*......P., D., I., Feb., 65
Curves, Experimental——, Methods for Determining the Equation of——. *A. S. Langsdorf*..........................P., I., June, 325

Description of Sewage Disposal Systems in Massachusetts. *X. Henry Goodnough* ....P., I., May, 213
Design of the Steel-Concrete Work of the Harvard Stadium. *Lewis J. Johnson* ....P., D., I., June, 293

Fallis, E. O. Theater Construction which Insures Public Safety. P., April, 189
Ferroinclave: A Fireproof Building Material. *H. F. Cobb.* P., I., Jan., 1
Filtration, Sand——, Adaptability of the Massachusetts Method of Intermittent——, to Sewage Disposal Problems in Other States. *F. Herbert Snow*................................P., D., I., May, 225
Fireproof Building Material, Ferroinclave: A——. *H. F. Cobb.* P., I., Jan., 1
Foundations, Timber Crib——. *Geo. B. Francis*......P., D., I., Feb., 65
Foundations for the Hotel Wollaton, Brookline, Mass., The Reconstruction of——. *Dana M. Pratt*.............P., D., I., March, 95
Francis, George B.
Timber Crib Foundations......................P., D., I., Feb., 65
Lackawanna and Wyoming Valley Railroad........P., I., March, 118

Geology, The Place of the Great Raised Beaches in——. *Herbert W. Pearson* ....P., I., Feb., 78
Golden, Walter L. Value of Inspection of Metal Bridges During Construction and Erection..............................P., March., 130
Goodnough, X. Henry. Description of Sewage Disposal Systems in Massachusetts ....P., I., May, 213
Greensfelder, A. P. Proposed Improvements in St. Louis Terminals. P., I., Jan., 11

Henry, Francis M. Rice in Texas and Louisiana..........P., April, 178

Inspection of Metal Bridges, Value of——, During Construction and Erection. *Walter L. Golden*........................P., March, 130

Johnson, Frank Prescott——. Obituary. Boston Society of Civil Engineers ....Feb., 92
Johnson, Lewis J. Steel-Concrete Work of the Harvard Stadium. P., D., I., June, 293

Lackawanna and Wyoming Valley Railroad. *George B. Francis.* P., I., March, 118
Langsdorf, A. S. Methods for Determining the Equation of Experimental Curves...................................P., I., June, 325
Lift Bridge, Scherzer Double-Roller——, Construction of a——, at Middle Seneca Street, Cleveland, Ohio. *William J. Carter* P., I., March, 113

PAGE

Massachusetts, Sewage Disposal Systems in——, Description of——. *X. Henry Goodnough* .... P., I., May, 213
McMath, F. C. Progress in Railroad Bridge Building .... P., June, 352
Methods for Determining the Equation of Experimental Curves. *A. S. Langsdorf* .... P., I., June, 325

Niagara Power, The Utilization of——. *H. W. Buck* .... P., I., June, 344

Obituary—
William C. Ogden, Boston Society of Civil Engineers ...... Feb., 91
Frank Prescott Johnson, Boston Society of Civil Engineers ... Feb., 92
Origin of the United States Land Surveys. *W. A. Truesdell.* P., April, 194

Pearson, Herbert W. The Place of the Great Raised Beaches in Geology .... P., I., Feb., 78
Place of the Great Raised Beaches in Geology. *Herbert W. Pearson.* P., I., Feb., 78
Pratt, Dana M. The Reconstruction of Foundations for the Hotel Wollaton, Brookline, Mass .... P., D., I., March, 95
Progress in Railroad Bridge Building. *F. C. McMath* .... P., June, 352
Proposed Improvements in St. Louis Terminals. *A. P. Greensfelder.* P., I., Jan., 11
Power, Niagara——, The Utilization of——. *H. W. Buck* .. P., I., June, 344

Railroad, Lackawanna and Wyoming Valley——. *George B. Francis.* P., I., March, 118
Railroad Bridge Building, Progress in——. *F. C. McMath* .... P., June, 352
Reconstruction of Foundations for the Hotel Wollaton, Brookline, Mass. *Dana M. Pratt* .... P., D., I., March, 95
Rice in Texas and Louisiana. *Francis M. Henry* .... P., April, 178

Sand Filtration, Adaptability of the Massachusetts Method of Intermittent——, to Sewage Disposal in Other States. *F. Herbert Snow* .... P., D., I., May, 225
Septic Tank, Use of the——, in Connection with Sewage Disposal Works. *Frank A. Barbour* .... P., D., May, 251
Sewage Disposal Problems, Adaptability of the Massachusetts Method of Intermittent Sand Filtration to——, in Other States. *F. Herbert Snow* .... P., D., I., May, 225
Sewage Disposal Systems in Massachusetts, Description of——. *X. Henry Goodnough* .... P., I., May, 213
Sewage Disposal Works, Use of the Septic Tank in Connection with——. *Frank A. Barbour* .... P., D., May, 251
Scherzer Double-Roller Lift Bridge, Construction of a——, at Middle Seneca Street, Cleveland, Ohio. *William J. Carter* .. P., I., March, 113
Snow, F. Herbert. Adaptability of the Massachusetts Method of Intermittent Sand Filtration to Sewage Disposal Problems in Other States. *F. Herbert Snow* .... P., D., I., May, 225

PAGE

Stadium, Harvard——, Steel-Concrete Work of the——. *Lewis J. Johnson*........P., D., I., June, 293

Steel-Concrete Work of the Harvard Stadium, Design of the——. *Lewis J. Johnson*........P., D., I., June 293

St. Louis Terminals, Proposed Improvements in——. *A. P. Greensfelder*........P., I., Jan., 11

Surveys, United States Land——, Origin of the——. *W. A. Truesdell*........P., April, 194

Tank, Septic——, Use of the——, in Connection with Sewage Disposal Works. *Frank A. Barbour*........P., D., May, 251

Terminals, St. Louis——, Proposed Improvements in——, *A. P. Greensfelder*........P., I., Jan., 11

Theater Construction which Insures Public Safety. *E. O. Fallis.* P., April, 189

Timber Crib Foundations. *Geo. B. Francis*........P., D., I., Feb., 65

Truesdell, W. A. Origin of the United States Land Surveys. P., April, 194

United States Land Surveys, Origin of the——. *W. A. Truesdell.* P., April, 194

Use of the Septic Tank in Connection with Sewage Disposal Works. *Frank A. Barbour*........P., D., May, 251

Utilization of Niagara Power. *H. W. Buck*........P., I., June, 344

Value of Inspection of Metal Bridges During Construction and Erection. *Walter L. Golden*........P., March, 130

Wickes, Geo. T. President, Montana Society of Engineers. Address. April, 202

Wollaton, Hotel——. Brookline, Mass.——, Reconstruction of Foundations for the——. *Dana M. Pratt*........P., D., I., March, 95

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FERROINCLAVE: A FIREPROOF BUILDING MATERIAL.

BY H. F. COBB.

[Read before the Civil Engineers' Club of Cleveland, December 8, 1903.*]

ON December 17, 1900, as many of you will remember, practically all of the buildings of the Brown Hoisting Machinery Company were destroyed by fire. The only exception was the pattern shop and office building, both of which were easily accessible to the firemen on account of surrounding driveways. The fire started in a gasoline tank, and in seven minutes it had traveled a distance of about 650 feet, through buildings which were considered a very safe risk by the fire insurance people. The walls were of brick, and the floor of 2-inch plank nailed to 4 x 4-inch stringers set in cinders. The roof was of 2-inch plank, covered with slate, and was supported upon steel trusses and columns. Since the roof and floor were practically the only parts of these buildings which could burn and since the distance from the floor to the ridge was about 46 feet, you may readily see why they were considered safe.

In view of the loss entailed by this fire, and of the much greater loss due to the interruption of our business at a time when we were crowded with orders, it is no wonder that Mr. Brown decided upon having the new shops constructed of fireproof material. Our main shop, in which we erect furnace hoists and other machines of great height, required a very complete crane service, with some of the cranes very high up. The ridge had to be about 87 feet from the floor. If the walls were built of brick, they would have to be

*Manuscript received December 17, 1903.—Secretary, Ass'n of Eng. Socs.

made very thick at the bottom, or else they would have to be supported on the structural work. In the first case, the cost of the wall would be high, and in the second case the cost of the structural work would be great. In order to light the shop to the best advantage, the saw-tooth construction was adopted. It was also decided that the floors should be of concrete. Mr. Alexander Brown invented a fireproof window sash, which we have since found to be most satisfactory. Thus we gradually determined what the general plan was to be, and began to look into details.

Among the first of these was the question of the kind of roofing. We wanted a fireproof roof which should be light, cheap and able to withstand the action of steam and sulphurous gases, which would not condense moisture badly and which should be a poor conductor of heat.

The only possibility in the way of a wooden roof would be one with sprinklers underneath. This, including the cost of nozzles, piping, tanks, etc., would have cost us upwards of $30 per "square" of 100 square feet. However, we wanted no wood in this building, so the great cost was not the only thing against this. Ordinary corrugated iron was not suited to the saw-tooth construction, on account of leakage and condensation. Also, it would increase the cost of heating, because it is a good conductor of heat.

Book tile, covered with slate, makes a good roof, but a very expensive one, on account of the great number of subpurlins required, and on account of its great weight, which necessitates heavy columns and trusses. Also, it is not well adapted to the saw-tooth construction.

Reinforced concrete roofs seemed to be the only ones which approached our requirements. Some of these were so made that a large part of the reinforcing metal was exposed on the under side. Of course, these could not last long, because the sulphuric acid and moisture, always in the atmosphere, would soon eat the metal away.

Some of the reinforced concrete roofs were made with the metal entirely imbedded in cinder concrete. Here again the metal would be eaten away. Also, where the concrete is made weak and the metal is not very strong, the thickness of the concrete must be several inches. This makes the roof heavy and thus increases the cost of the structural work.

In general, all of the reinforced concrete roofs, concerning which we could obtain any information, were too heavy and expensive, and required a tremendous amount of centering, which made the erection slow.

In putting up one of these roofs, the first thing is practically to build a wooden roof. Then a thin layer of rich concrete is spread evenly over the boards, and on top of this is placed the reinforcing metal. On top of this is then tamped some 2 or 3 inches of concrete, which is smoothed off and allowed to set for a week or more before the centering or wooden roof is taken down. If the under side is to look well, it must then be smoothed off by a plasterer, who puts on varying thicknesses of cement plaster until the marks of the centering boards are covered up. As the roof now has a large number of cracks in it, and as the concrete itself is not impervious to water, it is necessary to place on top about four plies of tarred felt, covered with pitch or asphalt and slag or gravel.

Mr. Alexander Brown determined that, since we could not buy what we wanted, we would make it. To do away with the centering, he made the reinforcing metal stiff enough to support the weight of the concrete. To make the concrete impervious, he used a richer mixture, one part of Portland cement to two parts of sand. At the same time, the stiffness and quantity of the reinforcing metal and the great strength of the concrete made it possible to obtain all the strength required with a roof only from one-half to one-third as thick and as heavy as any other. Hence, there was a saving in concrete and in structural work.

The two patents, which Mr. Brown took out, covered the shape of the reinforcing material and the method of forming it. This reinforcing material, which we now call "ferroinclave," is a corrugated sheet steel. The depth of the corrugations is $\frac{1}{2}$ inch, and the distance from center to center of each is 2 inches. On both the upper and the under side they are of a dovetail shape, with the

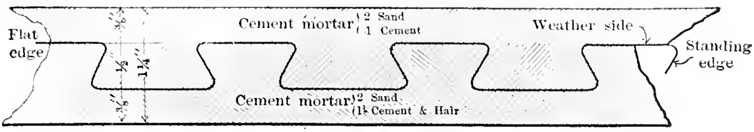


FIG. 1. SECTION OF COMPLETE ROOFING.

inner portion about $\frac{1}{4}$ inch wider than the outer. Fig. 1 is a section of a ferroinclave sheet, which is coated with concrete to the thickness used in the majority of roof constructions. Of course, the sheets had to be so formed that they would fit into each other and form a continuous surface. At the sides of the sheets this was an easy matter, because, if the last corrugations were left uncompleted, with the metal horizontal, they could be lapped and riveted. At the ends, however, a satisfactory joint could not be made without

shingling the sheets, and this made it necessary that the corrugations at one end of the sheet be wider than those at the other. You may readily see that the design of dies to form the ferroinclave was a difficult matter.

I will not describe the details of the machine, because you who are here to-night are interested more in results. Briefly, I would say that the ferroinclave is formed in two operations. The first one forms corrugations shaped like a wall tent. The second crushes down the ridge of this tent until its roof is flat.

The standard sheets, so formed, are 20 inches wide by 10 feet long, and of No. 24 gauge. We have crimped some sheets of No. 22 gauge, but not without springing the dies. Of course, lighter gauges can be formed, but, as there is no demand for them, we will not carry any in stock.

Besides the crimping machine, we have devices for sawing the sheets into shapes to fit gables, cornices, partitions, etc.; also a bending machine, operated by compressed air. This bends the standard sheets lengthwise into a trough shape for the construction of gutters (see Fig. 2), stair-treads, flashings, etc. Another device bends the sheets crosswise for the construction of ridges, valleys, flashings, gutters, etc.

In constructing a roof of this material, the ferroinclave is placed upon the purlins in much the same way that ordinary corrugated iron is laid. The only differences are that, with ferroinclave, a 3-inch lap at the top and bottom of the sheet is sufficient; also the ferroinclave does not rest directly upon the purlin, but bears upon a $\frac{3}{8}$ x $\frac{3}{8}$-inch wrought iron or hardwood strip, of which you will see the value later. Fig. 3 shows an I-beam purlin with a $\frac{3}{8}$ x $\frac{3}{8}$-inch strip on top supporting the ferroinclave. The clips, used for fastening the ferroinclave to the purlins (see Fig. 4), are riveted to the upper part of the corrugation, and securely grip the purlin. One of the two rivets in each clip fastens it to the upper sheet, and the other rivet takes hold of the lower sheet, because we are careful to have all end laps come directly over the purlin. Thus, the clips serve the second purpose of fastening the sheets together endwise. At the side the sheets are lapped about $\frac{3}{4}$ inch, and riveted about every 18 inches. Where there are no great irregularities in the roof, it is watertight as soon as the ferroinclave is laid.

The next operation, in the construction of the roof, is the concreting of the upper side. The mixture which we use is two parts of sand to one part of Portland cement. This is mixed on the ground and hoisted in pails to the roof. It is then spread evenly to a thickness of $\frac{3}{8}$ inch or more above the tops of the corrugations.

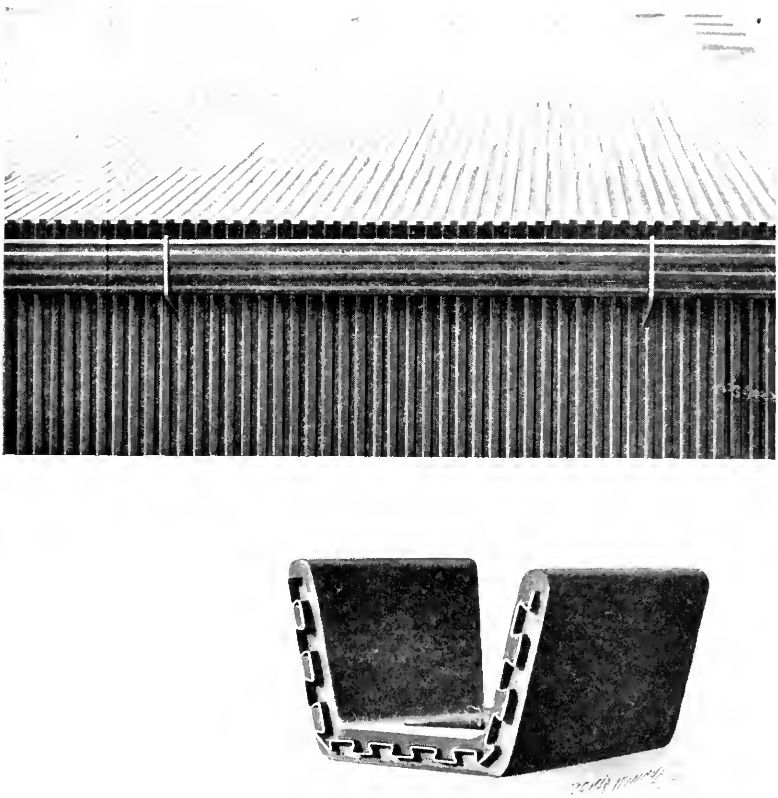


FIG. 2.

GUTTER IN PLACE, BEFORE CONCRETING,
AND
SECTION OF GUTTER, CONCRETED.

The ferroinclave is so stiff that the men may walk over it at will while they are doing this work.

On rainy days, and after the upper side is concreted, the

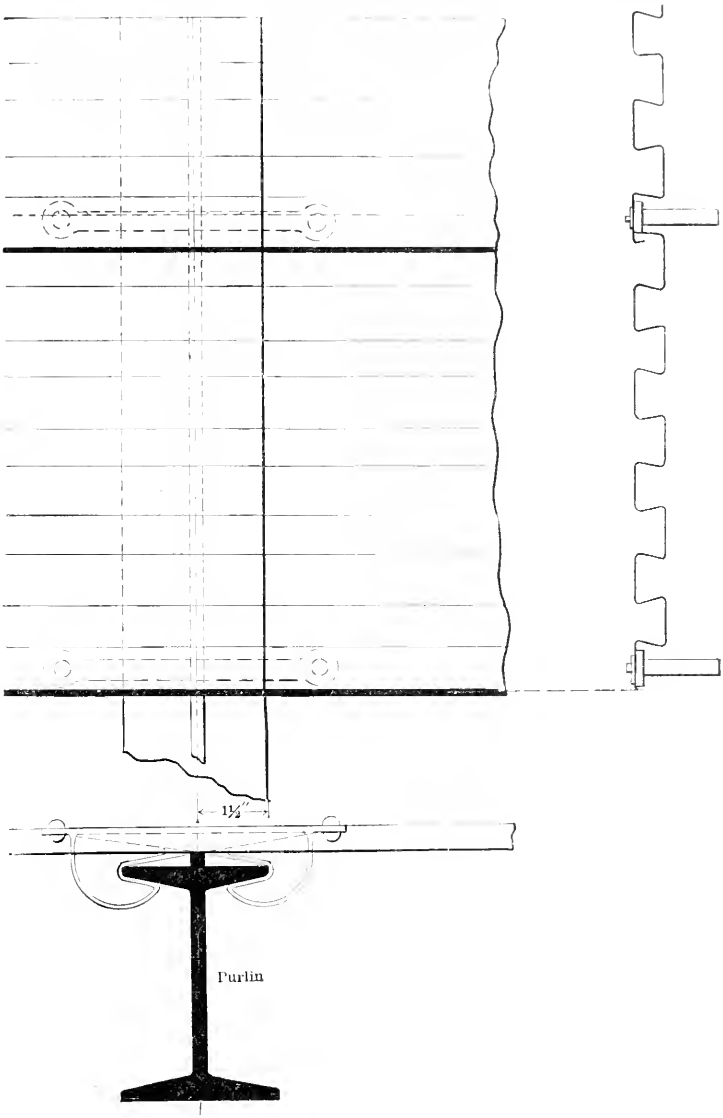


FIG. 3. SECTION THROUGH PURLIN AND FERROINCLAVE.

plasterers coat the under side with the same mixture of cement and sand, to which they add a small amount of hair. This is mixed very stiff and is put on in two operations. The first, or rough coat, just fills the corrugations. The second, or finishing coat, is $\frac{3}{8}$ inch

thick, and is finished usually with a floated or granular surface, which is afterward given a coat of cold-water paint, usually white.

Very often a few cracks may be formed in the concrete on the upper side, and the next operation is to grout these with a mixture of about one part of Portland cement to ten parts of water, put on with a paint brush. Thus, the roof is made a continuous concrete slab, $1\frac{1}{4}$ inches thick, and weighing fifteen pounds per square feet.

The roof is now watertight. The next question which arises is, will the roof be watertight when cold weather comes on? Will not the contraction of the roof cause large cracks to form, through which the rain will pass? The coefficient of expansion of steel is 0.0000065. The coefficient of expansion of the mixture of concrete which we use is 0.0000057. When the temperature outside the building changes the temperature of the roof changes, only not quite so much. Also, the temperature of the purlins changes, but to a less extent than that of the roof. Now, if the change in temperature of the purlins is about $\frac{57}{65}$ as much as the change in temperature of the roof, they will expand and contract together, and there will be no cracks. Also, if, by grouting the cracks at the right time, the roof can be kept in compression, a sudden heating of the purlins, or a sudden cooling of the roof, would only reduce the compressive force and perhaps put it slightly in tension.

Upon some roofs the conditions are very severe, and, as it is impossible to say that any roof will not have any especially rough treatment, that workmen will not make lifts by hanging tackle blocks to the purloins and thus cause them to sag, that a steam pipe will not burst and heat a short section of purlin or a small patch of roof and as many other things cannot be foreseen, we put upon the top of the concrete two heavy coats of our non-drying, waterproofing compound, so that such cracks as might afterward be formed will not permit rainwater to pass through. This compound is a heavy asphaltum paint, so prepared that it will not dry hard, like other paints, for several years.

One of the first buildings for which we furnished a roof was a difficult proposition, because the variation in temperature inside was about 400° F. This caused the purlins to expand and contract violently, and, as these changes in temperature were not communicated to the roof so rapidly or to such an extent, cracks were formed at intervals of about 15 feet. These opened and closed slightly. The method of construction adopted in this case was to grout the cracks, and, instead of waterproofing compound, to use a four-ply tarred felt roofing, stuck on to the concrete.

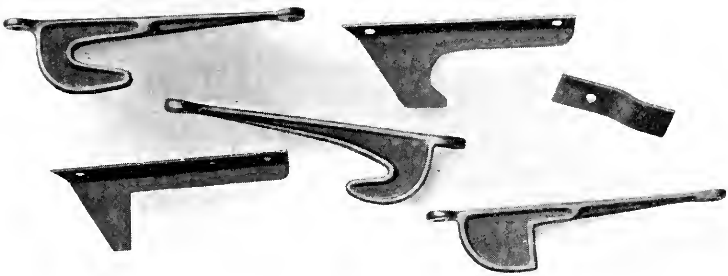


Fig. 4. Clips.

I have thus far confined my description to ferroinclave roofing, because what I have said about this will apply largely to other constructions. The construction of walls is the same, with the exception that, for the sake of appearance, they should be painted with cement wash upon the outer side. The ferroinclave may be fastened to the studs or girts, with the corrugations running either vertically or horizontally, preferably the latter.

Fig. 5 is a section through a window lintel and a ferroinclave wall, showing a good method of making their junction neat and

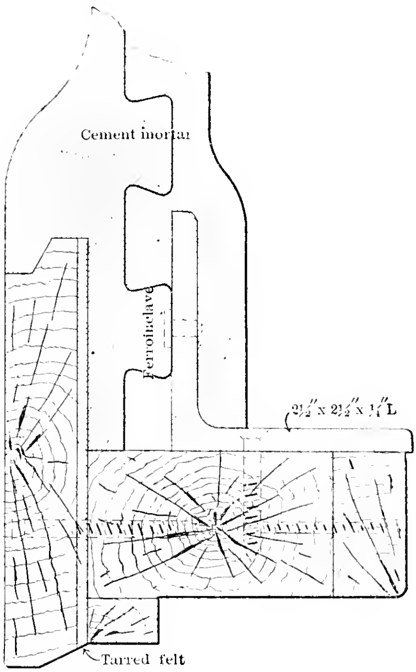


FIG. 5. SECTION THROUGH WINDOW LINTEL.

watertight. Equally good and perhaps better connections can be made around metallic window frames.

The spacing of the studs, like that of the purlins, may be any distance up to 9 feet 9 inches, although we consider 4 feet 10½ inches the best and cheapest.

Floors may be constructed in the same way as the roof, except that the thickness of concrete upon the upper side of the ferroinclave is increased to give the requisite strength. For instance, if the floor is to safely sustain a uniformly distributed load of 150 pounds per square foot on a span of 4 feet 10½ inches, center to center of floor beams, it will be necessary to put 1½ inches of con-

crete upon the upper side, making a total thickness of $2\frac{3}{8}$ inches. For a completely fireproof floor we cover the floor beams with wire netting and plaster cement mortar upon it. Colored tiles may be imbedded in the concrete, to form a wearing surface, or wooden nailing strips may be set in, so that a wooden floor may be put on top. Of course, the concrete itself makes a first-class wearing surface, and is quite good enough for factory use.

Stairways may be made by using channels or reinforced concrete beams at the sides and ferroinclave for treads and risers between.

A section through such a tread and riser is shown in Fig. 6. These treads may be concreted in a great many shapes and may be covered with tile, so as to present a very beautiful appearance. Figs. 7 and 8 show the ferroinclave stair-treads and partitions in our pattern shop.

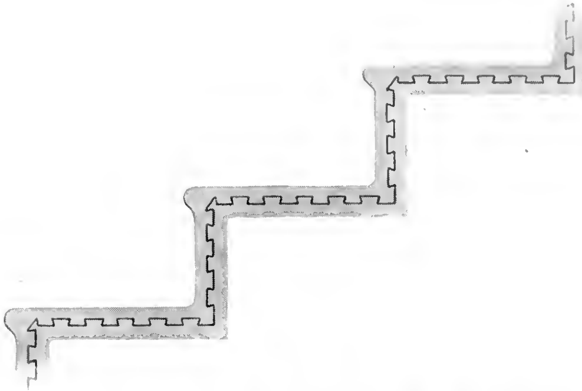
You will note that fireproof partitions are made in the same manner as ferroinclave walls. The structural supports may be wrapped with netting and cemented. Fireproof doors may be made by placing the ferroinclave in an iron frame.

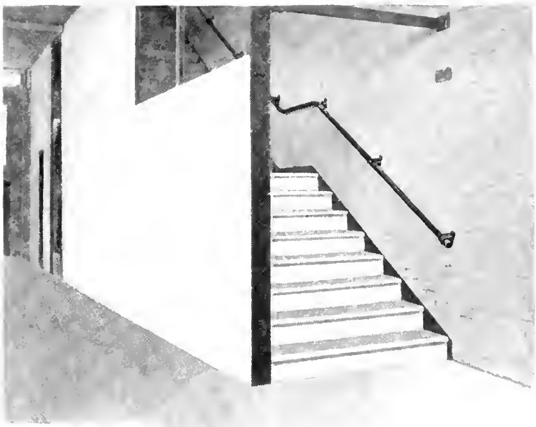
Reinforced concrete piles may be made by joining end to end a number of ferroinclave sheets, bending them into a pipe shape and concreting them inside and outside, so as to form a solid cylinder, as shown by Fig. 13. These piles are of great value, because of their indestructibility. They will have a great field of usefulness in tropical countries, where the teredo quickly eats out wooden piles, and steel piles are so soon rusted away. In other parts of the world wood is daily becoming more expensive, and as it lasts but a very short time in most cases, it is cheaper and safer to use concrete piles when preparing foundations for valuable and permanent structures.

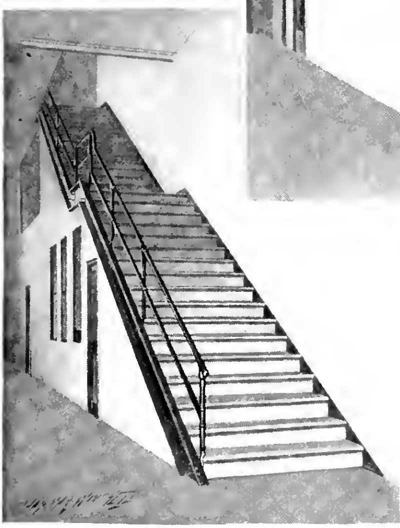
As we have not had an opportunity of collecting much data concerning these piles, I will not go into the matter further. During the coming spring we will make some very extensive tests.

The strength of ferroinclave constructions may be figured in much the same manner as other reinforced concrete constructions, except when the thickness of concrete upon the top of the ferroinclave is small. Then the stiffness of the ferroinclave gives material assistance, and part of the metal is in tension and part in compression. Hence, the only reliable way is to depend upon tests.

Figs. 9 and 10 show the results of a series of tests made upon No. 24 ferroinclave sheets, 20 inches wide by 10 feet long, placed upon two spans of 4 feet $10\frac{1}{2}$ inches each, and coated on the top with the various thicknesses of concrete, which are given as

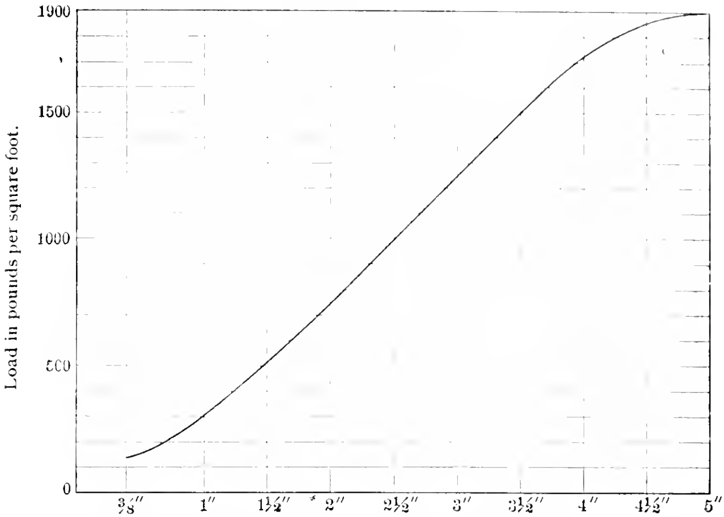






FIGS. 6, 7 AND 8. STAIRS.

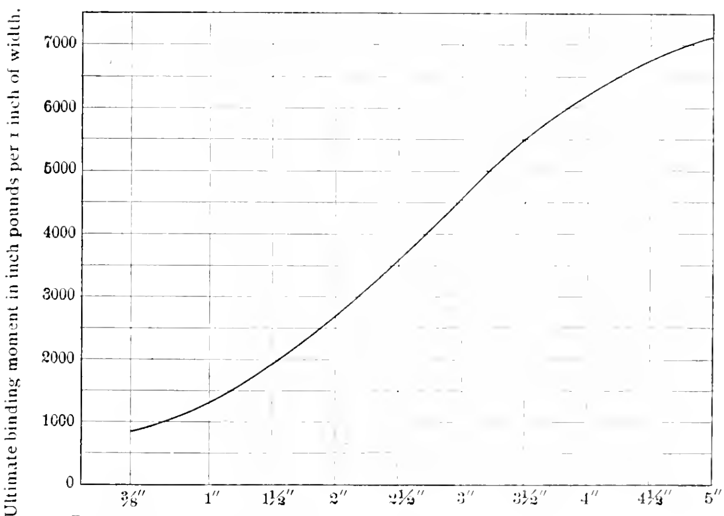
Curve of uniformly distributed loads per square foot, producing ½-inch deflection on a 4-foot 10½-inch span of No. 24 Ferroinclave, painted; then coated with cement, mortar and plaster. Time of setting, 14 days. Width of test pieces, 20 inches. Two spans.



Thicknesses of cement above Ferroinclave, 2 sand to 1 Vulcanite cement: ⅜-inch wall plaster (gypsum) below Ferroinclave.

FIG. 9. LOAD DIAGRAM.

Ultimate bending moments per 1 inch of width of No. 24 Ferroinclave, painted; then coated with cement, mortar and plaster. Two spans, each 4 feet 10½ inches. Tests made upon sheets 20 inches wide. Time of setting, 14 days.



Thicknesses of cement above Ferroinclave, 2 sand to 1 Vulcanite cement: ⅜-inch wall plaster (gypsum) below Ferroinclave.

FIG. 10. MOMENT DIAGRAM.

the ordinates of these curves. Figuring from these tests, we see that, when a ferroinclave roof is made $1\frac{1}{4}$ inches thick and placed upon a span of 4 feet $10\frac{1}{2}$ inches, it will support a uniformly distributed load of 50 lbs. per sq. ft. with a factor of safety of six.

Fig. 11 shows a simple fire test upon ferroinclave roofing. It is loaded to about fifty pounds per square foot and placed upon two spans of 4 feet $10\frac{1}{2}$ inches each. Fig. 12 shows the test pieces after the fire had burned for thirty minutes. Fire and water were alternately concentrated upon these sheets for about an hour, without doing any injury except to sag them very slightly.

Prof. Chas. L. Norton, of the Massachusetts Institute of Technology, who is in charge of the Insurance Engineering Experiment Station, states, concerning tests which he conducted, "The condition of the roof was such that it was still, at the close of the test, a good fire stop, and with a little more cement plastering it would have been in appearance and efficiency in its original condition."

A ferroinclave roof, when made only $1\frac{1}{4}$ inches thick, will conduct heat about $\frac{1}{20}$ as fast as corrugated iron and about six times as fast as 2-inch plank. No trouble has been caused by condensation of moisture upon the under sides in building which were properly ventilated. In buildings where there is liable to be a large amount of moisture, it is better to space the purlins a considerable distance apart, even up to 8 or 9 feet, and to make the roof a little thicker.

The cost of a ferroinclave roof, complete, varies from $20 per square of 100 square feet up to $26 per square when made $1\frac{1}{4}$ inches thick. It may be erected cheaply where plasterers are paid $3.75 per day and where conditions are favorable, and it will cost the maximum figure mentioned above when plasterers receive $7.50 per day of eight hours, as in one city which I might mention.

The average ferroinclave floor costs little more than the roof.

Ferroinclave walls cost from $22 up to $35 per square, depending upon locality, height, etc. Compare this with the cost of brick walls for our main shop, and you will see what a tremendous saving we made.

We sell the ferroinclave in sheets 20 inches wide by 10 feet long, or shorter. The price for the short sheets, and for those oddly cut or bent, is somewhat higher than for the standard 10-feet sheets.

Customers usually send us drawings of their buildings, and we give them prices for all of the ferroinclave and fastening clips required; or, if the buildings are large, we give them prices upon the roof, floor, walls, etc., complete and guaranteed.

Fig. 11. Fire Test, before Lighting.

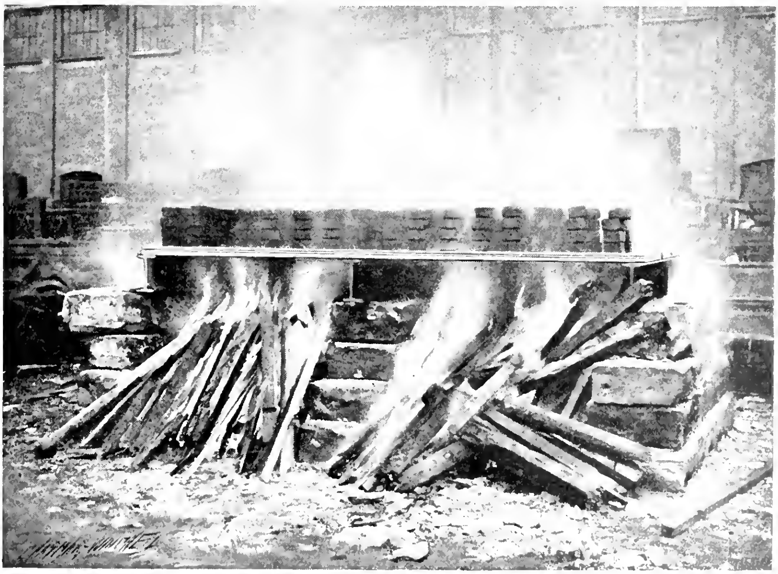


Fig. 12. Fire Test, One Hour after Lighting.

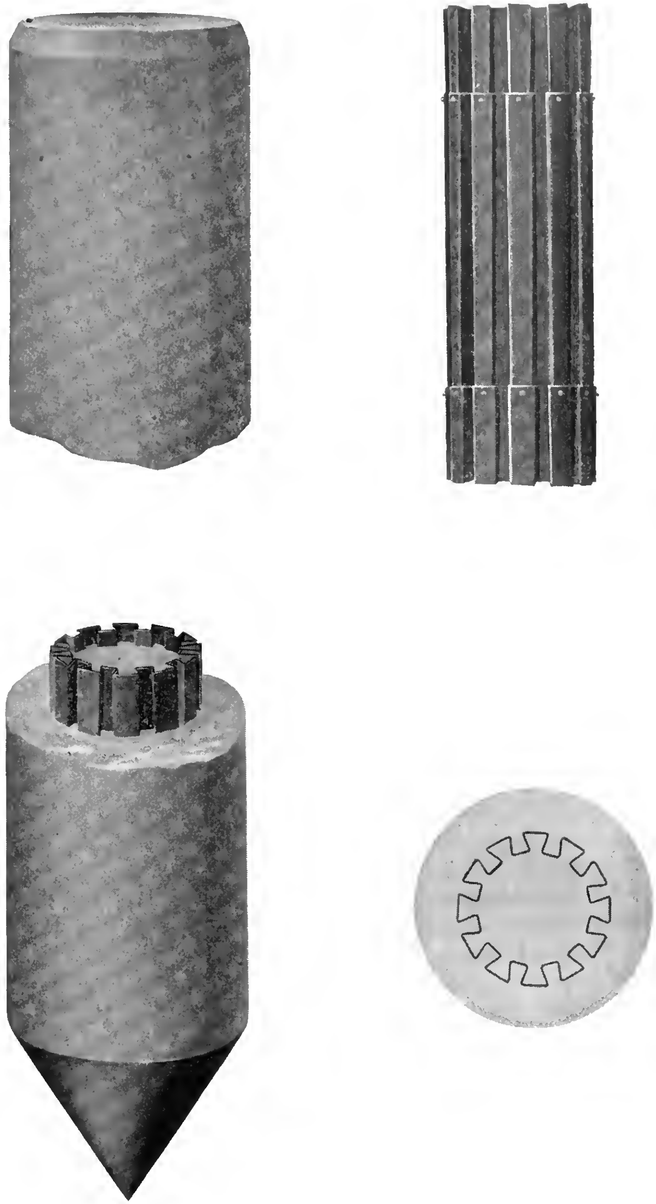


FIG. 13. FERROINCLAVE PILE.

PROPOSED IMPROVEMENTS IN ST. LOUIS TERMINALS.

By A. P. Greensfelder.

[Read before the Engineers' Club of St. Louis, October 7, 1903.*]

Prosperous times seem to come periodically in this American land, and with each period are associated some great forward strides in the development of its resources and in the improvement of the facilities for presenting these products for the benefit of its people. In the period just at hand out of all the numerous advances made in the arts and sciences none stand out more prominently than the progress shown in railroad construction and enlargement. The last few years have witnessed the spreading out of the numerous great trunk lines with wonderful rapidity throughout the United States, reaching out in all directions in order to keep up with the development of new territory or the tremendous increase in volume of business. This business, routed along the rails of all roads in the country, travels to the great business centers for further consignment or for commercial uses. Thus are brought to the large cities great numbers of cars, loaded or unloaded, through-billed or for transfer, for local industrials or for consumption.

Such a town is St. Louis, with a population fourth largest in the United States, the center of twenty-two different railroads, and she presents quite an example of what railroad concentration can imply. Each town in the Union has its problem of the hand ling of the varied railroad freight and passenger business for solution, and this city on the banks of the Mississippi is not an exception. Chicago, Pittsburg, Philadelphia and Boston have each been compelled recently to consider the enlargement and betterment of their railroad terminals; and St. Louis, just reaching that point where business warrants and compels it, has not been slow in expanding and improving to meet existing and future conditions.

Here, in St. Louis, all passenger business is handled from one union station, and a great quantity of local freight and of freight interchange is transferred from one railroad to another, through the medium and under the direction of what is known as the Terminal Railroad Association, or T. R. R. A., of St. Louis.

The T. R. R. A. of St. Louis is an association of fourteen of the twenty-two railroads entering St. Louis or East St. Louis, and was formed by them for the economical and rapid handling

*Manuscript received November 23, 1903.—Secretary, Ass'n of Eng. Socs.

of passenger and freight business through the city. Up to about a year or so ago, its proprietary lines were six in number, and included the Missouri Pacific, the Iron Mountain, the Wabash, the Big Four, the Baltimore and Ohio and the Louisville and Nashville. With the recent addition of the 'Frisco, the Vandalia and the Rock Island, and then the Chicago and Alton, the Southern, the Illinois Central, the Burlington and the Missouri, Kansas and Texas, as proprietary lines, together with the tremendous increase in business within the last few years which it has been compelled to handle, the T. R. R. A. has been made a center of railroad interests of large proportions. In this way, due to ever-increasing business in both freight and passenger channels, the Terminal Association has been compelled to make large additions to, and important improvements in, its facilities. These improvements are partly under way of construction at this time, others have recently been completed and still others are contemplated, but work on them has as yet not been started. It is of these improvements that I will speak in a general way to-night. I will endeavor not merely to recite facts and figures in an offhand way, which might mean nothing except to a railroad man personally acquainted with the present situations, but will try to show the reason for the changes and improvements, and to what extent these alterations will prove beneficial—not only the what, but the reason why and the way how we expect to remedy existing conditions.

For the convenience of the operating department the Terminal properties are divided into four districts, namely, the East St. Louis, the Madison, the Bremen Avenue and the St. Louis Districts. (See Fig. 1.)

The East St. Louis District extends from the stockyards in East St. Louis to East Carondelet, and exercises jurisdiction over the east approach of the Eads Bridge, the tracks in vicinity of relay depot, the freight ranging yards just north of Cahokia Creek and the Conlogue branch to the East Carondelet Ferry. One of the largest improvements in this district is the enlargement of the ranging yard, in which all carload freight received in East St. Louis is separated and classified according to the various roads. The old yard had a capacity of about 1500 40-foot cars, but, with the addition of the new westbound departure yard of 485 cars capacity, and the extension of the eastbound receiving yard to hold 230 cars additional, the capacity of this yard will be increased about 50 per cent. to a total of 2250 cars. The increase in capacity of this yard is essential in order to insure reasonably prompt movement of the extra 1000 cars which are moved in the fall and winter

over and above the daily average of about 3000 freight cars in the St. Louis and East St. Louis Districts. The westbound yard, as built, is somewhat of a novelty in this vicinity, it being what is known as a gravity-switching or "hump" yard. The yard, since it was opened last January, operates very satisfactorily and breaks up a train very rapidly, although its efficiency is somewhat impaired by the fact that there are only 16 tracks in the yard, holding 25 to 35 cars each. The hump is 8 feet above the south end of the yard, and has a 2.4 per cent. grade up and a 3.4 per cent. grade down for 100 feet, when it spreads out to a 0.42 per cent. through the switches on the lead for 1000 feet and then level for 600 feet down the yard. A very large scheme of a cluster yard was worked out for this point, comprising a series of classification yards, in which were arranged a 40-track westbound and southbound classification and departure yard, holding 2000 cars; a 20-track eastbound receiving yard, holding 1100 cars; an eastbound classification yard of 24 tracks, holding 600 cars; an eastbound departure yard of 30 tracks, with a capacity of 1600 cars, and a westbound departure yard of 40 tracks, holding 1000 cars, making a grand total of 6300 cars; but, due to the radical changes necessary in the relocation of the tracks of numerous lines, this scheme was found impracticable.

Relay depot, situated between the head ends of several freight yards, in a triangle of bad railroad crossings, where passenger business to and from Eads Bridge is heavy, and where engine relays are made, is a point which early called for some kind of an interlocking plant to govern train movements. In 1883 the first large interlocking plant of the kind in the country was installed here, and used hydraulic transmission of power. This plant was somewhat altered in 1888, and remodeled into a 71-lever hydro-pneumatic plant. Having run its life since then, it was decided last year to install the latest type of an electric system, and the Taylor Signal Company will be ready within a few weeks to turn over for operation a plant controlled through a 144-lever machine, 104 levers of which are working levers. The plant is modern in every respect, with clay wire conduits, dwarf and high signals, electrically lighted, reserve storage batteries, duplicate power plants and convenient signal bridges.

The Madison District geographically presents itself next for consideration, including, as it does, the territory from Granite City, on the north, down along the east approach of the Merchants Bridge, through Madison and Madison Yards to the Illinois Transfer Railroad and the East St. Louis Belt Line, to the stockyards

in the south. At Granite City, where connection is made for the Merchants Bridge with the Wabash, the Big Four, the Chicago and Alton and the Chicago, Peoria and St. Louis, it will be necessary to remodel the present interlocking plant in order to insure safety to the high-speed runs, which are made at 60 miles an hour through this point by the limited through passenger trains. It is contemplated to substitute for the present mechanical machine of 68 levers, which was installed by the Johnson Signal Company in 1894, with its old mechanical switch-lock movements and out-of-date signal devices, a plant, either power-operated or mechanical, fully equipped with facing point and position locks and all modern improvements.

At Madison Junction, where freight trains to and from Madison Yard leave or enter the tracks leading to Merchants Bridge, without protection to the passenger trains of the northern roads using this bridge, it was deemed necessary to remedy this dangerous condition by the installation of an interlocking plant at this point. Accordingly, a Taylor electric machine of 55 levers is being installed, with proper derails, home and distant signals, signal bridges, etc.

At the Madison Freight Yard, wherein is received and classified freight for numerous lines, as well as all freight routed via Merchants Bridge, in order to reduce the engine mileage to its normal condition, it is necessary to increase the number of tracks. For example, during 1902 the engine days worked increased 65 per cent. over the same period in 1901, while there was only 31 per cent. increase in the number of cars handled. The present plans contemplate, therefore, the enlargement of a yard of 17 tracks, with a total capacity of 600 cars, to a yard with a greater number of tracks and increased car capacity.

On the Illinois Transfer Railroad, which is the outer belt on the east side of the river, connecting with the Illinois Central on the south and with all intersecting lines to the Clover Leaf on the north, and with Madison Yard, there is being laid a long piece of double track to accommodate the rapidly increasing traffic which is properly being handled along this belt.

At a point on the East St. Louis Belt Railroad, where it crosses the Venice and Carondelet Railroad, is a triangular tract of ground of about 20 acres. On this space there are now being built an engine house and repair shops of large capacity, in order to afford proper facilities for the maintenance and repair of the locomotives and car equipment of the company. With the new equipment, which it is intended to purchase, there will be about 100 locomotives to

be provided for, and a large repair yard is necessary. The only shops now maintained are some old buildings at Sixteenth Street, in St. Louis, which it will be necessary to dismantle in order to provide space for other improvements, while the present facilities for car repairs consist merely of small outbuildings scattered through the various yards. It is the intention, therefore, to transfer all repair work of this kind to these new shops, which are very complete and extensive and involve the expenditure of about half a million dollars. The layout includes a roundhouse, machine shop, blacksmith shop, wood and paint shop, storehouse, oil house and power house, and it is intended to provide, at some future time, not only repair tracks of all kinds, but a modern engine-coaling station as well. (See Fig. 2.)

The 80-foot engine roundhouse, of 16 stalls, is modernly equipped with cleaning and wheel pits, is hot-air heated and electrically lighted and is reached through a 70-foot turntable.

The arrangement of shops is such that, by means of the 70-foot transfer table, 304 feet long, of 150 tons capacity, operated by electricity along their entire length between the adjoining machine and blacksmith shops and the wood and paint shops, an engine or car can be brought from the engine house or through the repair yard and run directly to the place desired. The shops are composition-roofed, brick buildings and are designed to fit each its special purpose. The machine shop, 253 feet by 123 feet, is equipped with an 80-ton crane, to enable the shifting of a locomotive bodily, and is well arranged, with its large tools on the ground floor and its lighter tools economically placed on a balcony above. The 75-foot by 123-foot blacksmith shop is equipped with two turntables, serving the forges and machines. The wood and paint shop is 110 feet long by 100 feet wide, and is to handle all wood work for both engines and cars. The two-story storeroom and office building, 128 feet by 53 feet, is located alongside of convenient tracks, and is easily accessible to the material yard and shops.

The 100-foot by 98-foot power house is built sufficiently large to permit installation of more machinery than the present 1000 horse power required to heat, light and furnish power to the various buildings of the group. The equipment is machinery transferred from the present power house at Union Station, St. Louis, and consists of four 250-horse-power Babcock-Wilcox water-tube boilers, three 200-horse-power Erie vertical marine engines, one 350-horse-power Ingersol-Sergeant air compressor of 2150 cubic feet per minute capacity, pumps, etc., and a new 10-ton 42-foot hand-operated crane.

Before turning our attention from the east to the west side of the Mississippi River it may be of interest to mention some work being done on the two connecting links between the Missouri and Illinois Shores.

On the east approach of the Eads Bridge there is now being reconstructed a portion of the railway viaduct between bent 30 and the east abutment, including the long continuous 322-foot $3\frac{7}{8}$-inch girders originally built, and of which style of construction, I believe, there are not many examples in the country. This reconstruction is necessary because that part of the structure will not be strong enough for those new switching engines which the company has ordered, as well as for new road engines of ever-increasing weight. On the main spans of the Eads Bridge, consisting of the center span of 520 feet and two side spans of 502 feet each, a very thorough inspection was made last year, and the bridge was found in remarkably good condition after its thirty years of incessantly heavy service since July 4, 1874. A number of very interesting points were brought out in this inspection, but one in particular showed how well planned and how carefully executed was every detail of manufacture of the material and its erection in this bridge. In order to investigate the strength of the ribs on the main arches it was decided to drill holes through the envelope and staves which go to make up these hollow ribs, which are about 18 inches in diameter. These staves, varying in thickness from $1\frac{1}{8}$ inches to $1\frac{1}{2}$ inches, are made of the toughest 100,000-pound chrome steel, and it was only with the greatest difficulty that we succeeded in piercing them. Nearly a dozen holes were drilled in various spots on the bridge, and in every case we found the inside of the tube in almost as perfect condition as on the day when it was put in place. By means of a unique contrivance of mirrors and electric lights we were enabled to look down inside of the hole, and the original paint coating was found intact. It may be necessary, however, where the outer 5-16-inch envelope has been badly eaten away, to cover the ribs with a new $\frac{3}{8}$-inch envelope, jacketed over the present one, with a filling between of new asphalt.

Some renewals are also being made in the floor beams on the upper roadway, which, being freely exposed to the sulphur, smoke and steam of the engines running beneath them, have been somewhat weakened by corrosion. In addition some gusset plates are being added to the verticals supporting the upper roadway, but, with the exception of the placing of some rigid bracing between these posts, nothing radical is being done whatever on the main

spans. Due to the gases and moisture in the tunnel on the west approach of this bridge, the old steel bridges over Main Street, Second Street and the alley between have badly deteriorated, and are being replaced with entirely new structures.

On the Merchants Bridge, east approach, nothing is being done with the exception of the replacing of the four 67-foot 6-inch girders over Kline Street, which were washed out by the flood in June. An estimate of cost for replacing the one remaining piece of wooden trestlework on this bridge just east of the three 125-foot spans on the east approach was made, and it is not unlikely that this work will be done in the near future.

On the main spans of the Merchants Bridge, in order to secure to the bridge ample strength for the new road engine loading of two 174-ton engines with tenders, involving 50,000 pounds on driver axles, spaced 4 feet 6 inches center to center, as well as for the new terminal switching engine of shifter type, with 68 tons on three driving axles having 11-foot wheel base, and 112 tons total weight of engine and tender, it was found advisable to combine under one track, the four stringers which were previously under the two, and to replace those shifted with two new ones. This work has been completed, and both tracks are now in full service.

On the west approach of Merchants Bridge, the old wooden trestlework, erected when the bridge was built, in 1892, has been replaced with a modern steel viaduct, and a new northwest approach steel viaduct has been built, to make connections with the west belt line. The viaduct is about 35 feet high, with 28-foot towers and 28-foot spans, and is about 820 feet long.

Running off from the Merchants Bridge toward the west, we enter the so-called Bremen Avenue District, which extends from Biddle Street through the Florida Street, Ashley Street, Bremen Avenue and May Street yards toward the northwest belts. What is known as our West Belt Line here extends from its connection at Carrie and Bulwer Avenues westwardly around the city to a connection with the Wabash Railroad near Page Avenue. Good progress has been made on this line recently, and it will shortly be completed, with 5.1 miles of double-track line. The line is located with 8-degree curves and compensated 1 per cent. maximum grades, and is almost entirely free from grade highway or electric railway crossings, which are carried either above or below its tracks. It is the intention to use this belt line for the transfer of through freight destined for points outside of St. Louis, thus contriving to keep out of the crowded Mill Creek Valley this traffic, which unnecessarily tends to congest it. It is possible also that,

during the World's Fair, it may be found desirable to run passenger trains around this belt line, in order to increase the facilities for carrying people to and from the World's Fair Grounds.

There is also being built an outer belt line, known as the St. Louis Belt and Terminal Railway, which runs 16.4 miles, from its connection with the Burlington at Prospect, on the north, around the city to the 'Frisco, at Lindenwood, on the south, connected en route with the Wabash, Rock Island and Missouri Pacific. With its 0.8 per cent. limiting compensated grades, and its 4-degree maximum curves, it is bound to become a busy freight channel for that through business requiring rapid transit, a demand which seems to be yearly increasing, and which develops a tendency to keep such traffic out of the large cities with their consequent terminal delays.

Due to the belt lines and increasing freight tonnage over the Merchants Bridge, the Bremen Avenue District is handling more business every year, so that it is found necessary to enlarge the present Bremen Avenue Freight Yard from its present capacity of 92 cars to hold about 197 cars additional, in order to take care of the necessary distribution at this point. It is also the intention to erect at this point a passenger station of ample capacity.

All passenger trains, from Union Station to the Northern lines and over the Merchants Bridge, are compelled to come down Main Street, which is a public thoroughfare. Due to wagon traffic in this street, and to the great amount of switching in and out of the numerous industrial plants and small yards of the Burlington Railroad and the Terminal Company, this passenger traffic is often blocked. In order, therefore, to reduce these delays to a minimum, a third track has been laid along Main Street, giving a double main-line track from the Union Station, and a system of electric interlocking is being installed between Biddle Street and North Market Street. Due to obstruction of view, three towers are necessary, and a 96-lever machine (70 working) has been placed at North Market Street, a 36-lever machine (24 working) at Mullanphy Street and a 36-lever machine (23 working) at Biddle Street. Due to the location of the tracks in the paved street and the consequent wagon usage, detector bars at switches were found impossible, and track circuits had to be resorted to for indication of train movements. This is somewhat of an experiment in a spot where short circuits are easily caused by muddy streets and by ice and snow in winter, but it is thought that this can be overcome by careful installation.

Following along the Main Street tracks, we enter, at Wash-

ington Avenue, what is known as the St. Louis District, which runs west from this point through Mill Creek Valley and Union Station to Grand Avenue. The changes in this district are most radical, and improvements of a large scope are being inaugurated in order to relieve congestion throughout the valley and to take care of the anticipated extra traffic due to the World's Fair, to be opened on April 30, 1904.

One of the largest improvements suggested, and one which has created a great deal of popular discussion, through the newspapers, at least, is the proposed double track connection between Eads Bridge and the Merchants Elevated tracks, commonly known as the "Loop." This plan contemplated the building of a steel elevated structure, about 2200 feet long, from a connection with the tracks on Eads Bridge just west of the main spans, and curving westward and southward on a down grade until it ran parallel to and on a level with the present elevated Merchants tracks at a point near Market Street. In addition it was proposed to four-track, from Market Street around to Twelfth Street, the present double-track Merchants Elevated, a distance of about 6600 feet, thus affording a four-track channel to and from Union Station. This scheme involved the expenditure of a large sum of money, and was undertaken with the idea of obviating the so-called tunnel nuisance to passengers traveling via Eads Bridge, and to increase the capacity of Eads Bridge with the consequent betterment of service on the main line tracks between relay depot and Union Station.

The avoidance of smoke and gases in the tunnel is impossible because of the extremely heavy traffic at busy intervals of the day, and of its location in the heart of the business part of St. Louis, where ventilating shafts would not be tolerated. The actual operating time limit between the following trains through the tunnel is about four minutes, due to the fact that its cross section prohibits proper curve elevation around a curvature of $11\frac{1}{2}$ degrees. The following, from the train sheet of October 3, 1903, shows the average daily traffic through the tunnel and over the Eads Bridge in twenty-four hours:

Eastbound—	
Passenger trains	53
Freight trains hauling 532 cars	23
Light engines	22
Total	98

Between 7.25 and 9.42 A.M. were run 16 trains.
Between 8.29 and 10.13 P.M. were run 15 trains.
On four-minute, least schedule.

Westbound—

Passenger trains	52
Freight trains hauling 669 cars	29
Light engines	14
Total	95

Between 6.58 and 8.25 A.M. were run 14 trains.
Between 6.12 and 8.27 P.M. were run 16 trains.
On three-minute, least schedule.

The tunnel grades are 80 feet to the mile, and in its construction, sufficient provision not having been made for drainage, perfect track maintenance is difficult.

The smoke, besides being distasteful to the traveling public, is also a serious detriment to train operation, for its density is such as to prevent positive observation of any signals placed in the tunnel, and compels the establishment, for absolute safety, of the positive block, which makes it impossible for the entrance of one train into the tunnel until a preceding train on that track has cleared the exit at the other end. It is thought, therefore, that the building of the "Loop" and of the two additional elevated tracks would, in a large measure, prevent the delays caused by volume of traffic and by the failure of inbound trains to reach East St. Louis on schedule time, and that the separation of freight from passenger traffic at Main Street, and the running of the former only through the "Hole," would enable prompter service to be given in every way.

In the Mill Creek Valley itself the rearrangement of tracks and yards will be so thorough that the present railroad map through this territory will scarcely be recognizable. The present Twelfth Street classification yard will be increased in capacity 10 per cent. from its total of 133 cars, but the Fourteenth Street team yard will be moved and three new engine houses built there, each to be served by electric transfer tables. About 200 car capacity of the present Sixteenth Street freight team yard, including the coal business, will be removed to Compton Avenue, leaving only about 158 car capacity of the yard for team delivery of carload merchandise, enabling us, therefore, to increase our Seventeenth Street coach storage yard from a capacity of 75 cars to hold at least 235 80-foot coaches. The removal of the present engine house and machine shops to East Madison will enable us to place in that locality an engine-coaling yard, to accommodate all eastern and terminal engines using Union Station. The coaling yard will be centered about a 1000-ton capacity coaling station, equipped with all the latest devices for the rapid watering, coaling and sanding

of engines. Cleaning pits will be located beneath the building, enabling the ashes, as well as all coal and sand, to be handled with link-belt machinery.

The area just east of Twenty-first Street, cleared of the team yard, transferred to Compton Avenue, and the old coach storage yard, moved to Atlantic Street, has been covered with a new small coach-storage yard of about 90 cars capacity, intended to hold special and private cars near the station, where they may be quickly reached in making up trains, and also with a 45-car head-end yard, provided with 10-foot roadways between tracks and timber-floored throughout to enable access by both trucks and wagons to such train head-end stuff as baggage, milk, theatrical paraphernalia and carload mail. In the same vicinity, just east of the new express houses to be rebuilt, on the west side of the approach into Union Station, in order to enable the laying of the new track arrangement at that point, is also built an express yard, holding about thirty cars, and so arranged that each of the express houses will have trucking access to two tracks. (See Fig. 3.)

Between Ewing and West Jefferson Avenue is being built a coach-storage yard, large enough to accommodate 245 80-foot cars, with additional repair capacity of 20 cars. This yard will provide for all coaches taken from the present Twenty-first Street District, and some in addition. A small power house, of 250 horse power, is being installed in this yard to furnish steam for car heating. Air for cleaning purposes and for air-brake testing, as well as water for washing cars, is being piped all over, and the yard is to be provided with convenient coal bins, car-repair store-rooms, wheel yards, etc., so that economical care of coaches is insured. (See Fig. 4.)

At Compton Avenue, the present team yard of 232 cars capacity will be enlarged to hold about 630 cars. In this bulking yard will be handled large quantities of coal and carload goods of all kinds, destined for local consumption in the central and western part of the city. The present plans contemplate the building, from Grand Avenue to Union Station, of two main-line tracks, on which to handle all western passenger business and to direct its movements into the station. At the station itself improvements of large conception are being carried out, all of which are designed to increase, in various ways, the present cramped facilities at this Union Station, which, when it was opened for service, September 2, 1894, was thought to be so large that it would require a city growth of at least twenty-five years before it wou'd be overtaxed in any manner.

The St. Louis Union Station handles a kind of business peculiarly its own; for, instead of being a terminal station in the true sense of the word, such as Boston or New York, or an intermediate station, such as Pittsburg or Philadelphia, it is essentially a transfer station. Lines from the East, West, North and South bring in solid trains of cars, which, almost without exception, stop at this point, but each of which brings passengers, mail, baggage and express for interchange and distribution among all others. Another fact explaining the necessity for large train space is that the percentage ratio of suburban and through traffic, as compared with other large cities, is remarkably small. Out of the 135 outbound and 135 inbound daily trains, scheduled on a time-table dated August 30, 1903, not more than 10 per cent. is suburban business. However, it is believed, that if the capacity of the present 32 tracks in the train shed, which now hold trains of from 4 to 10 cars, is increased, by lengthening all the tracks to a uniform capacity to hold 10 or 11 cars, it will be readily possible to take care of all business by providing, at the same time, sufficient outside coach-storage room to obviate the necessity of using the train shed for that purpose, and also, by so arranging the leads into the train shed that accumulative delays due to fog or unusual conditions are reduced to a minimum.

The present track layout shows four tracks in the neck of the lead approaches into the train shed; but, due to the lack of proper connections and to the necessary method of handling business, seldom more than three and usually not more than two simultaneous moves are permissible at this point. With the purposed arrangement, resembling in appearance two huge bottles, it will be possible to make six parallel moves through the necks, and, with the numerous cross-overs and double slips, the number of possible moves will be almost unlimited. (See Fig. 5.) With the head house on Market Street fixing the location on the north, and the Missouri Pacific tracks determining the southern limit, the only possible directions for enlargement of the present track plan were east and west, and compelled the relocation of the express buildings and power house. In addition to the six main leads above mentioned, movements to and from the yards will be possible along the adjacent express, coach-storage and engine leads. This radical track rearrangement necessitated the replacement of the present large 131-lever electro-pneumatic plant now in operation, with an entirely new system of interlocked switches and signals.

Due largely to the manner in which business must be handled, and partly to the arrangement of present tracks, the number of

trains moving into and out of the station, necessary to receive and dispose of a train are very great. Each train movement requires the throwing of several levers on the interlocking machine, and the number of lever movements for one day is very large. For comparison we have the following for May 11, 1902, as taken from a report by the former superintendent of telegraph, Mr. E. A. Chenery:

Description.	St. Louis Union Sta.	Boston North Sta.	Boston South Sta.	Pittsburg Penna. R. R. Sta.
Scheduled trains, in and out..	224	606	775	....
Light engine movements....	736	....	....	....
Switching movements	573	....	....	....
Passenger movements	364	....	....	....
Freight movements	162	....	....	....
Total train movements	1,835	2,637	2,500	5,349
Total lever movements......	24,956	22,220	27,621	39,419
Average train movement per train scheduled	8.19	4.35	3.36	7.37
Average lever movement per train scheduled	111.41	36.66	36.93	....

In explanation of the fact that, while South Boston has nearly four times as many trains as we have, our train movements are nearly as large and our average moves per train are 145 per cent. greater, it is only necessary to study the head-end movements for handling baggage, mail and express. Taking as one example the make-up of an evening western passenger train, we have the following:

1. Switch engine with coaches and sleepers into train shed.
2. Switch engine light out of train shed.
3. Switch engine light into mail track.
4. Switch engine with mail car out of mail track.
5. Switch engine with mail car into train shed.
6. Switch engine light out of train shed.
7. Switch engine light into express track.
8. Switch engine with express car out of express track.
9. Switch engine with express car into train shed.
10. Switch engine light out of train shed.
11. Road engine light into train shed.
12. Train complete out of train shed.

Instead of one tower, as at present, due to the great distance covered on the new plan, and the convenient grouping of switches, and to train movements at certain points, it is thought better to subdivide the machine into three towers, interlocked between themselves, and governed by a chief operator located at the central station. These three towers, combining in one system 215, 47

and 47 levers respectively, will control the largest interlocking plant in the world.

COMPARISON OF INTERLOCKING SYSTEMS.

Description.	St. Louis New Union Sta.	St. Louis Present Union Sta.	Pittsburg Penna. R. R. Sta.	Boston South Sta.
Year installed	1903	1893	1902	1899
Number of towers	3	1	4	3
Total number of levers	309	131	287	165
Total number of working levers	258	101	242	150
Number levers in largest machine	215	131	131	143
Total number of switches operated	107	61	68	57
Total number of double slips (M. P. F.)	65	12	76	39
Total number of signals operated	235	105	167	144

The Union Switch and Signal Company's electro-pneumatic system is being installed, and it is assured, with the scheme for handling trains over the new layout, that both the train and lever movements will be materially reduced. The 99-foot by 146-foot power house, as relocated near Eighteenth Street Bridge, will be fireproof throughout, and will have a capacity of 2750 horse power. The ten pairs of boilers, fed by automatic stokers drawing from coal automatically delivered, are connected to a large stack 200 feet high. The Westinghouse marine and compound engines are directly connected to generators delivering current at high voltage for light and power. The mechanical equipment includes, besides the usual complement of pumps and feed-water heaters, air compressors, etc., three pumps for operating the (39) hydraulic elevators in the proposed baggage and mail buildings and in the subway system to be presently described. For moving machinery in the engine room a 15-ton, 42-foot, hand-power crane has been installed.

New Express buildings are being built for each of the Adams, Pacific, American, Wells Fargo and United States Express Companies. This group comprises a solid block, extending southwardly from Twentieth Street and Clark Avenue, and is to be two-storied, with basement, brick, slow-combustion buildings, furnishing a large percentage of increase in room required to handle the expanding business. A new large baggage building and a mail building have been planned, and are to be erected in the near future directly adjacent to the train shed. The train shed is being extended 180 feet south, in order to protect the longer trains possible under the

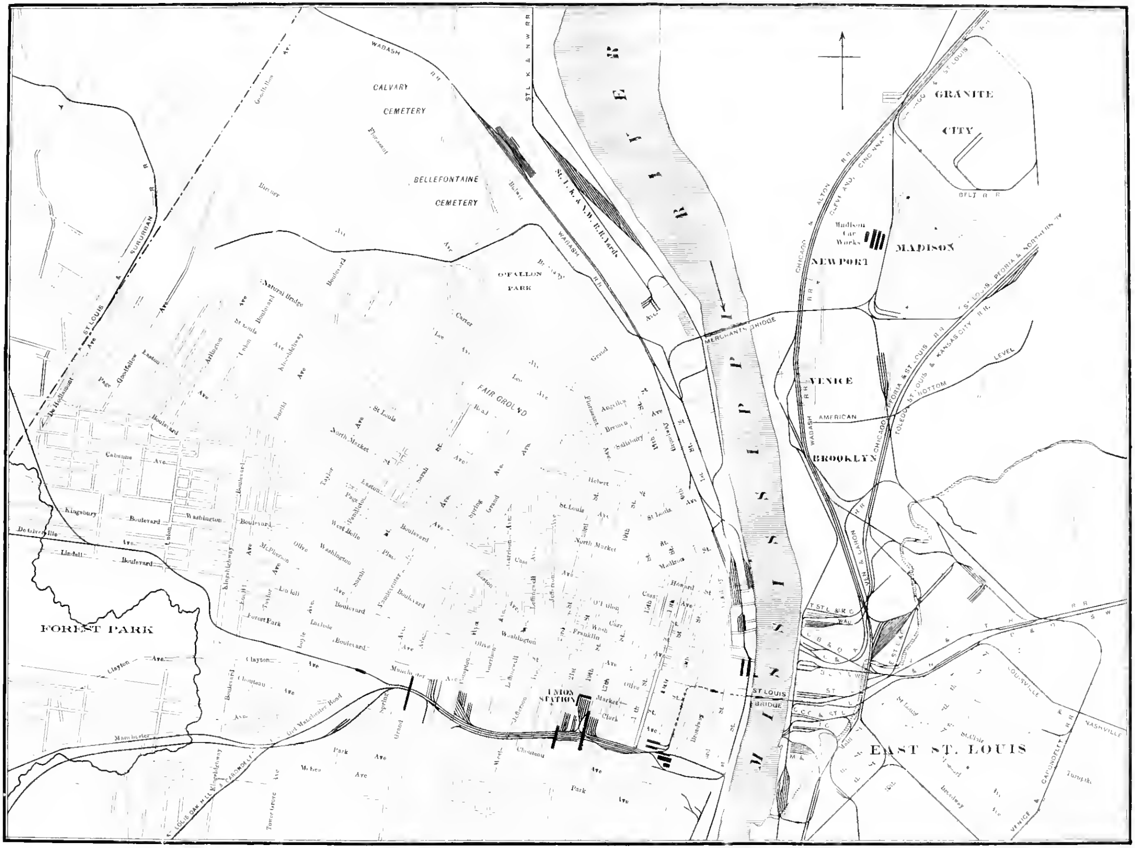


FIG. 1. PLAN OF ST LOUIS AND EAST ST. LOUIS, SHOWING RAILWAY SYSTEM OF THE TERMINAL R ASSOCIATION OF ST LOUIS. FEBRUARY, 1897

Scale, 6 inches 1 mile

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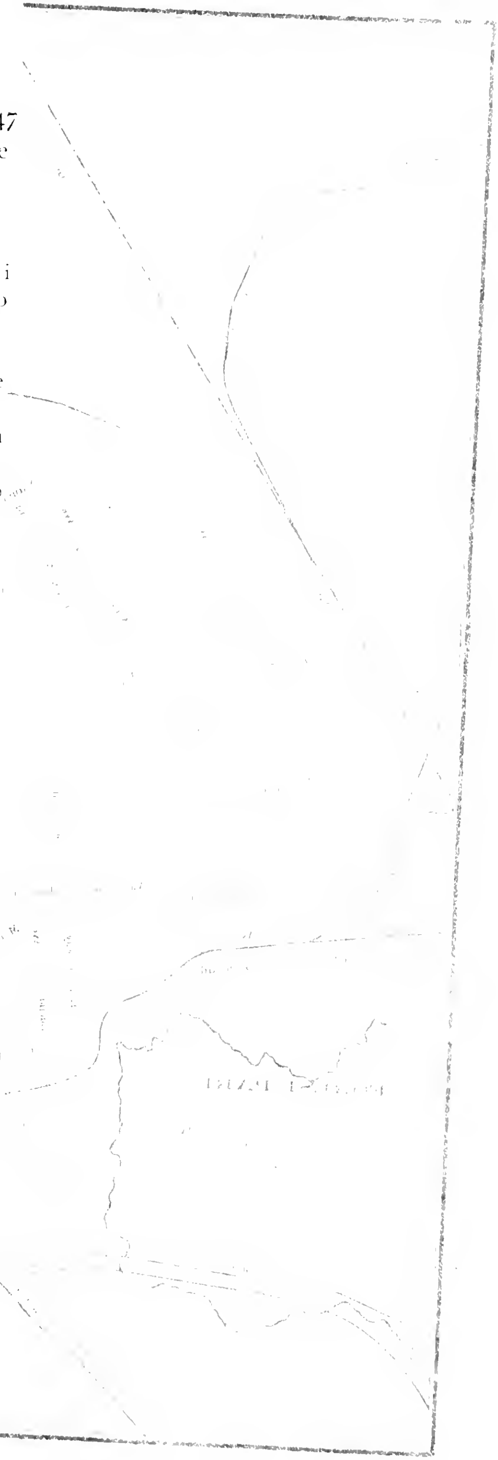

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FIG. 2. GENERAL PLAN OF PROPOSED ENGINE YARD AND REPAIR SHOPS AT CROSSING OF THE EAST ST. LOUIS BELT AND VENICE AND CARONDELET RAILROADS NORTHWEST OF ST. LOUIS NATIONAL STOCK YARDS. OCTOBER 10, 1902.

Scale 1 in. [illegible] feet

FIG. 3. PLAN, SHOWING PRESENT AND PROPOSED TRACKS IN VICINITY OF UNION STATION. DECEMBER 8, 1902.

Scale 1 inch = [illegible] feet

FIG. 4. [illegible] OF YARDS [illegible] AUGUST [illegible]

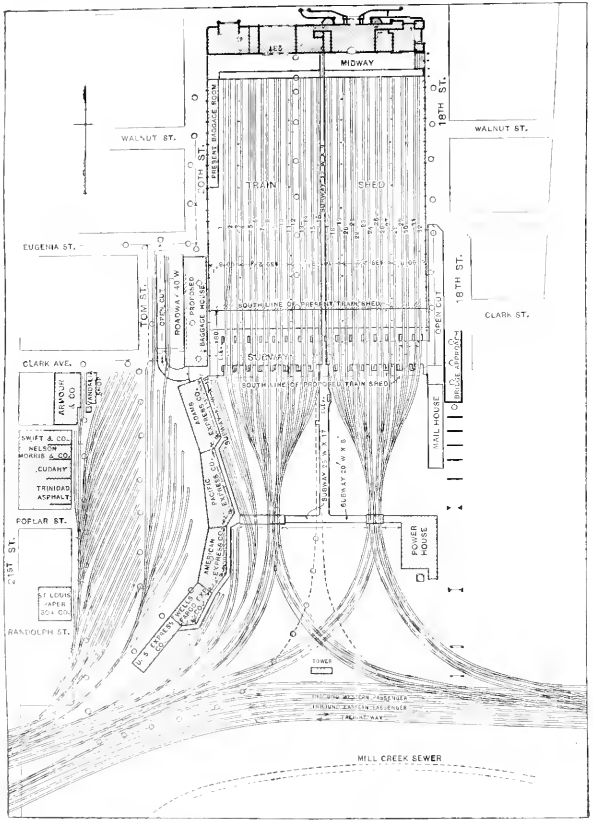


FIG. 5. PROPOSED REARRANGEMENT, UNION STATION AND VICINITY. JANUARY, 1903.

Scale, 1 inch = 350 feet.

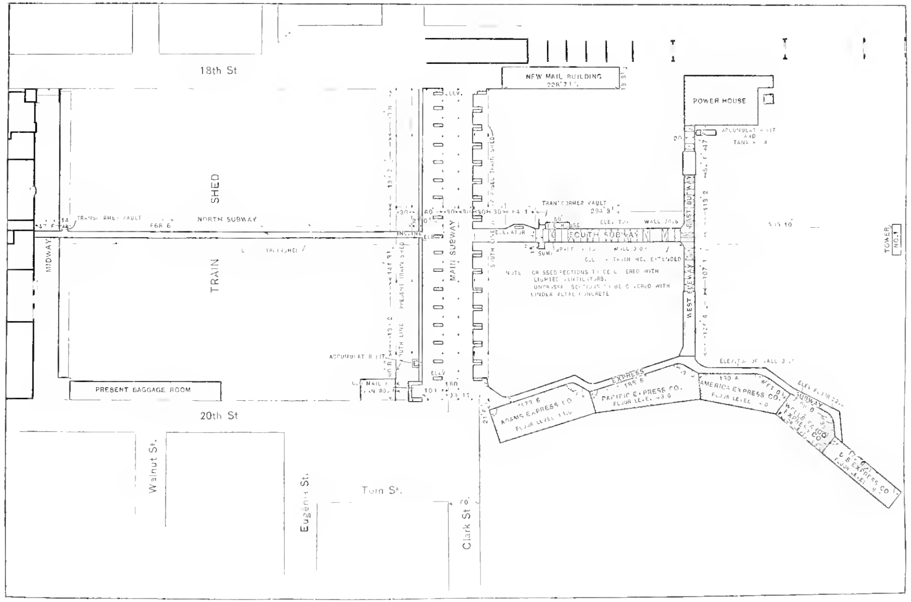


FIG. 6. GENERAL LAYOUT OF SUBWAYS, UNION STATION. JULY, 1903.

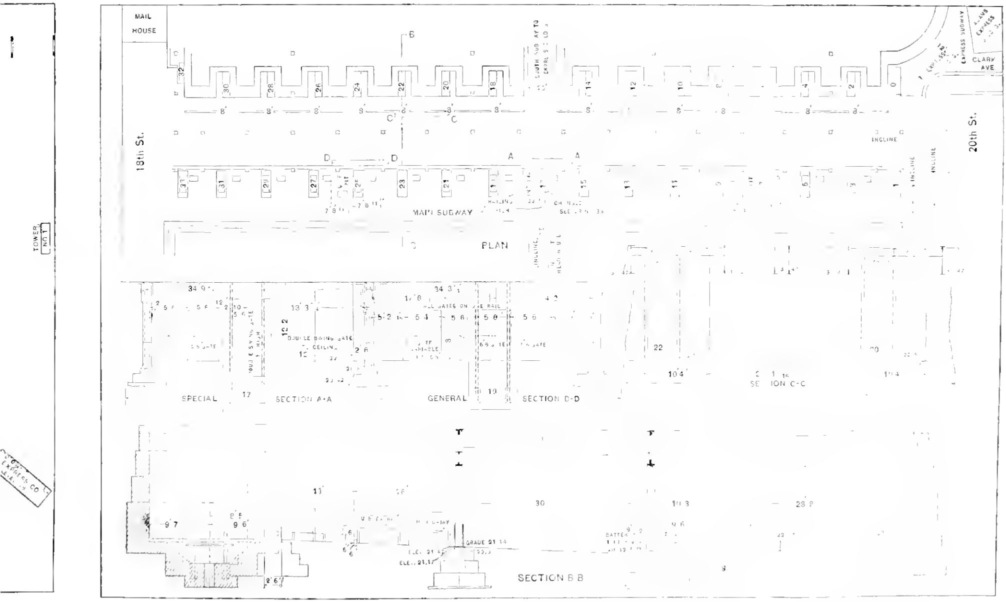


FIG. 7. GENERAL PLAN AND SECTIONS OF MAIN SUBWAY, UNION STATION. JULY 21, 1903.

Scales, 0.01 inch and 0.05 inch = 1 foot.

new plan, and also shield the main subway built beneath the tracks. The train shed, exclusive of the midway (70 feet by 601 feet), will then be the largest in the country, if not in the world, and will cover (601 feet by 810 feet long) 11.18 acres and contain 6 miles of track.

In connection with all these Union Station improvements there is being built, to facilitate the handling of baggage, mail and express, a large system of underground subways. This subway scheme, embodying a very comprehensive plan for the rapid handling of all baggage and such portion of the mail and express business as is handled in the train shed on trucks, is believed to be an entirely new departure on such a large scale from any existing facility of the kind ever constructed in a large railway station. Its usefulness, in particular, is due to two general principles: First, that business requiring to be handled in a limited space of time is so located and concentrated as to give short hauls, and yet is not so crowded as to interfere with rapid movement; and, secondly, that the grade crossing of trucks and trains is eliminated. These two things are desirable at any station, but particularly so in St. Louis where trucking distances are very great and where interference of business, due to the crossing on grade of trucks and cars, is very serious.

The truck runway, crossing the tracks at this station, is near the south end of the train shed, and in the busy morning and evening periods, when trains are arriving and departing every minute or so, when switching movement is almost continuous and when rapid interchanges of large quantities of baggage, mail and express are necessary, the congestion is very great. Another feature which adds to the time of delays is the fact that it is necessary to cut long trains at this runway in order to leave the passage open. Then, when the train is still within a few minutes of leaving time, the train must be backed together and coupled up, in order to try air-brakes and connections. The subway plan will obviate all this interference and delay, and, because of its large scope, it should serve for a number of years the rapid and economical handling of this class of matter.

For convenience, the subway system is divided into the Main Subway and the North, South, East and West and Express Subways. (See Fig. 6.)

The Main Subway, paralleling the south end of the train shed and crossing each of the 32 tracks, runs from Eighteenth Street to Twentieth Street, a distance of 600 feet, and has a width of three ordinary streets, or about 120 feet. This 120 feet is divided, by

two rows of columns and the south wall, into a 40-foot baggage storeroom on the north side, equipped with an elevator between every two pairs of tracks; a 30-foot street adjacent for use of baggage wagons; another 30-foot street for use of mail and express wagons and trucks, and the south 20 feet for a line of elevators to be used for express and mail of all kinds. (See Fig. 7.)

These elevators are large enough for truckloads of baggage 4000 pounds in weight, and run at rate of 150 feet per minute from the subway floor either to the platform above or to the height of the platform of a car, 4 feet more. Approaches to the Main Subway are to be built from both Eighteenth Street and Twentieth Street, so that there will be a wagon entrance at both ends. Wagons loaded with baggage, mail or express can then come from any part of the city, drive into the main subway, stop immediately underneath the train for which its material is destined, load its contents either on trucks or on the elevator and have it raised rapidly to the cars already coupled on the trains. The north 40 feet of this subway is provided with the necessary gates, scales and check devices for the rapid handling of baggage as delivered.

The North Subway is a small subway running north and south under the train shed, from the head house to the Main Subway, between tracks 16 and 17. It is 12 feet wide by 9 feet clear, and is to be used for trucking hand baggage from a receiving check room, to be placed in the main waiting room, to the Main Subway. It will also serve to carry a number of pneumatic tubes between the same points, to be used as a means of transmitting baggage checks, similar to the operation of such tubes in department stores. There will be room also for steam pipes and wires, etc., up to the head house. The South Subway, running south from and in the center of the Main Subway, is merely a connecting link between it and the East and West Subways. It is 25 feet wide by 12 feet clear, and has along its walls niches for a sump, a transformer vault and an ice storehouse of small capacity.

The East Subway runs from the South Subway over to the power house, and, although 20 feet wide, has only 8 feet clearance for the passage of numerous pipes and wires from the power house.

The West Subway is a continuation of the East Subway, extending west from the South Subway to the express building. It is 20 feet wide by 12 feet clear.

The Express Subway is a small subway 12 feet wide by 14 feet clear, running parallel to all the express buildings and connecting same to the West and Main Subways. The basements of all the express buildings are on the same level as the subway floor.

Each express building is equipped with elevators, and it is expected that trucks will be taken from these buildings via the Express or West and South Subways to the elevators along the south wall of the Main Subway, and up these to the cars.

It is the intention to connect the basements of the baggage and mail buildings with the subways in the same manner as the express buildings.

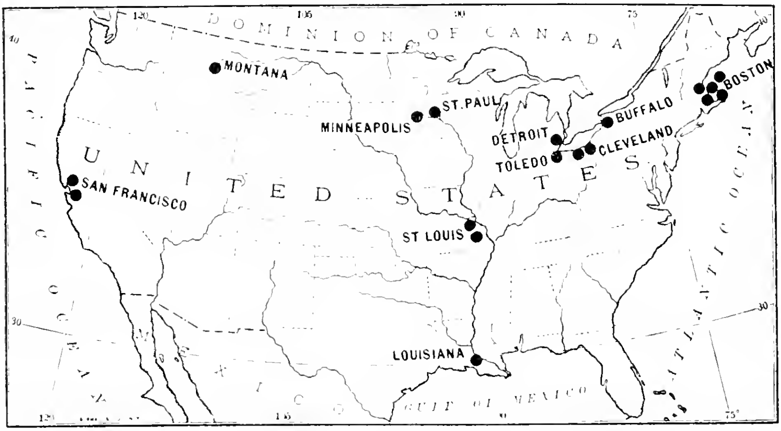
The above describes, in a hasty manner, the idea of the subway system, but I will not at this time go into details of its construction or design, but will merely add that the subways are to be roofed over and well paved. A heavy steel girder construction is employed to carry the tracks over the Main Subway.

The foregoing description of the various improvements covers, I believe, in a general way, the work being done or contemplated in the near future, but, in order to refrain from taking too much of your time, I have not mentioned many of the things embodied in the construction of yards and buildings under the very wheels of frequent traffic, or of details in design. The work is being executed at the cost of millions of dollars, and had not the city fathers been so unwise as to discourage improvements in railroad entrance ways to St. Louis it is likely that even still greater undertakings would have been built.

With the improvements and additions mentioned, however, and with present ones already in service, together with the additions and changes which nearly every road entering this territory is making on its own accord, I have no hesitancy in saying that St. Louis, in her railroad facilities, will be second to no city in the Union.

In making proper acknowledgment I should like to add that all these improvements are being made under the direct supervision of Mr. W. S. McChesney, Jr., president and general manager; Mr. Daniel Breck, general superintendent, and Mr. J. L. Armstrong, engineer, Maintenance of Way. Mr. E. F. Kearney is superintendent; Mr. T. N. Gilmore, master mechanic; Mr. G. F. Brooks, track supervisor, and Mr. J. A. Johnson, signal engineer, for the T. R. R. A. The St. Louis Belt and Terminal has Mr. B. E. Johnson for its chief engineer.

The writer, as assistant engineer to the Terminal Railroad Association, is particularly in charge of construction work in the St. Louis District, and has the able assistance of Mr. E. C. Dicke. Messrs. Brenneke & Fay have looked after steel-work design; Westinghouse, Church, Kerr & Co. are providing power, and Percival & Jones are installing elevators.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

ASSOCIATION OF ENGINEERING SOCIETIES.

Articles of Association.

The following Articles of Association were adopted at a meeting held in Chicago, December 4, 1880. At this meeting there were present representatives of the

Western Society of Engineers,
Civil Engineers' Club of Cleveland,
Engineers' Club of St. Louis,

and the

Boston Society of Civil Engineers

was represented by letter.

FOR THE PURPOSE OF SECURING THE BENEFITS OF CLOSER UNION AND THE ADVANCEMENT OF MUTUAL INTERESTS, THE ENGINEERING SOCIETIES AND CLUBS HEREUNTO SUBSCRIBING HAVE AGREED TO THE FOLLOWING

ARTICLES OF ASSOCIATION.

ARTICLE I.

NAME AND OBJECT.

The name of this Association shall be "THE ASSOCIATION OF ENGINEERING SOCIETIES." Its primary object shall be to secure a joint publication of the papers and the transactions of the participating Societies.

ARTICLE II.

ORGANIZATION.

SECTION 1. The affairs of the Association shall be conducted by a Board of Managers under such rules and by-laws as they may determine, subject to the specific conditions of these articles. The Board shall consist of one representative from each Society of one hundred members or less, with one additional representative for each additional one hundred members, or fraction thereof over fifty. The members of the Board shall be appointed as each Society shall decide, and shall hold office until their successors are chosen.

SEC. 2. The officers of the Board shall be a Chairman and Secretary, the latter of whom may or may not be himself a member of the Board.

ARTICLE III.

DUTIES OF OFFICERS.

SECTION 1. The Chairman, in addition to his ordinary duties, shall countersign all bills and vouchers before payment and present an annual report of the transactions of the Board; which report, together with a

synopsis of the other general transactions of the Board of interest to members, shall be published in the JOURNAL OF THE ASSOCIATION.

SEC. 2. The Secretary shall be the active business agent of the Board and shall be appointed and removed at its pleasure. He shall receive a compensation for his services to be fixed from time to time by a two-thirds vote. He shall receive and take care of all manuscript copy and prepare it for the press, and attend to the forwarding of proof sheets and the proper printing and mailing of the publications. He shall have power, with the approval of any one member of the Board, to return manuscript to the author for correction if in bad condition, illegible or otherwise conspicuously deficient or unfit for publication. He shall certify to the correctness of all bills before transmitting them to the Chairman for counter-signature. He shall receive all fees and moneys paid to the Association and hold the same under such rules as the Board shall prescribe.

ARTICLE IV.

PUBLICATIONS.

SECTION 1. Each Society shall decide for itself what papers and transactions of its own it desires to have published, and shall forward the same to the Secretary.

SEC. 2. Each Society shall notify the Secretary of the minimum number of copies of the joint publications which it desires to receive, and shall furnish a mailing-list for the same from time to time. Copies ordered by any Society may be used as it shall see fit. Payments by each Society shall in general be in proportion to the number of copies ordered, subject to such modification of the same as the Board of Managers may decide, by a two-thirds vote, to be more equitable. Assessments shall be quarterly in advance, or otherwise, as directed by the Board.

SEC. 3. The publications of the Association shall be open to public subscription and sale, and advertisements of an appropriate character shall be received, under regulations to be fixed by the Board.

SEC. 4. The Board shall have authority to print with the joint publications such abstracts and translations from scientific and professional journals and society transactions as may be deemed of general interest and value.

ARTICLE V.

CONDITIONS OF PARTICIPATION.

SECTION 1. Any Society of Engineers may become a member of this Association by a majority vote of the Board of Managers, upon payment to the Secretary of an entrance fee of fifty cents for each active member, and certifying that these Articles of Association have been duly accepted by it. Other technical organizations may be admitted by a two-thirds vote of the Board, and payment and subscription as above.

SEC. 2. Any Society may withdraw from this Association at the end of any fiscal year by giving three months' notice of such intention, and shall then be entitled to its fair proportion of any surplus in the treasury, or be responsible for its fair proportion of any deficit.

SEC. 3. Any Society may, at the pleasure of the Board, be excluded from this Association for non-payment of dues after thirty days' notice from the Secretary that such payment is due.

ARTICLE VI.

AMENDMENTS.

These articles may be amended by a majority vote of the Board of Managers, and subsequent approval by two-thirds of the participating Societies.

ARTICLE VII.

TIME OF GOING INTO EFFECT.

These articles shall go into effect whenever they shall have been ratified by three Societies, and members of the Board of Managers appointed. The Board shall then proceed to organize, and the entrance fee of fifty cents per member shall then become payable.

These articles were adopted by the several Societies upon the following dates:

Engineers' Club of St. Louis, January 5, 1881.
Civil Engineers' Club of Cleveland, January 8, 1881.
Boston Society of Civil Engineers, January 19, 1881.
Western Society of Engineers, April 5, 1881.

The Board of Managers was organized at a meeting held in Cleveland, Ohio, January 11, 1881.

The following Societies have since certified their acceptance of the articles, and have become members of the Association of Engineering Societies:

Engineers' Club of Minneapolis, July, 1884.
Civil Engineers' Society of St. Paul, December, 1884.
Engineers' Club of Kansas City, January, 1887.
Montana Society of Civil Engineers, April, 1888.
Wisconsin Polytechnic Society, June, 1892.
Denver Society of Civil Engineers, January 24, 1895.
Association of Engineers of Virginia, February 1, 1895.
Technical Society of the Pacific Coast, March 1, 1895.
Detroit Engineering Society, January, 1897.
Engineers' Society of Western New York, January, 1898.
Louisiana Engineering Society, September 15, 1898.
Engineers' Club of Cincinnati, January, 1899.
Toledo Society of Engineers, January 11, 1904.

The Wisconsin Polytechnic Society withdrew from the Association in March, 1894.

The Western Society of Engineers withdrew in December, 1895.

The Engineers' Club of Kansas City disbanded at the close of 1896.

The Denver Society of Civil Engineers and the Association of Engineers of Virginia disbanded in 1898.

For the Engineers' Club of Cincinnati see footnote to Appendix F, Secretary's Annual Report for 1902, Vol. XXX, No. 1, page 57, January, 1903.

RULES.

(A) RULES OF THE BOARD OF MANAGERS.

Adopted, Chicago, June 11, 1881. Vol. I, No. 1, November, 1881, page 5.

1. Questions may be decided without a meeting of the Board, by correspondence. Motions shall be made and seconded and then forwarded to the President, and by him communicated to each member of the Board, to be voted upon by letter ballot.

2. Motion unanimously adopted favoring an independent monthly publication, embracing in each issue the proceedings and papers of each Society.

3. On motion, it was decided that the matter of each Society should be placed separately in the pamphlet, under the proper heading, the positions to be arranged in the order of the rate of organization.

Adopted, New York, June 22, 1882. Vol. II, No. 3, January, 1883, page 107.

4. Each assessment proportioned to the Societies on the basis of the number of copies of the JOURNAL taken at the time the assessment is made.

Adopted, New York, September 4, 1884. Vol. III, No. 12, October, 1884, page 329.

5. That the names and addresses of the officers of each Society be printed upon the second page of the cover of the JOURNAL.

6. That in the opinion of this Board it is desirable that papers read before the Societies of this Association should not be published in professional periodicals previous to being published by the Association; that there is no objection to publishing them in whole or in part in local newspapers.

7. That the Secretary be instructed to insert in the JOURNAL the following: Editors reprinting articles from this JOURNAL are requested to credit both the JOURNAL and the Society before which such articles were read.

8. That the Chairman be authorized to arrange for publishing in the JOURNAL an index of engineering reports and Society transactions, and abstracts of such reports and transactions as may be found desirable.

Adopted, Chicago, September 11, 1891. Vol. X, No. 10, October, 1891, page 511.

9. A discussion on the value and quantity of matter sent to the Secretary for publication resulted in the opinion that final control should rest with the Board.

The following suggestions of a committee were adopted:

10. That, beginning with the January number, 1892, a Secretary be employed at a salary of not to exceed $600 per annum, who shall conduct all the correspondence and other business pertaining to the office, and who shall also be employed to publish the JOURNAL at standard current prices, keeping a strict account of all receipts and expenditures, and render an account of the same to the Chairman of this Board, on whose approval the accounts may be allowed.

11. That the Chairman of the Board should audit all bills and accounts, and collect from each Society, quarterly, their pro rata of the estimated net cost of the publication, and at the end of each volume he should make a report to the Board, to be published in the JOURNAL, giving a classified statement of all receipts and expenditures, which report should be subject to the inspection and approval of the Board.

12. That each Society in the Association be allowed one-half the receipts from all advertisements sent in by its Secretary to the JOURNAL, and that such sums be placed to its credit on the Secretary's books and deducted from its pro rata portion of the cost of publication, and that the same commission be allowed the Secretary of the Board, in addition to his salary, on all new advertisements he may procure.

Adopted, Chicago, August 3, 1893. Vol. XII, No. 7, July, 1893, page 380.

13. Rules governing the Election of Officers of the Board of Managers of the Association of Engineering Societies:

(1) The term of office of the Chairman and that of the Secretary and Treasurer shall be two (2) years, and shall begin on January 1st, of the even years, but they shall remain in office till their successors are chosen.

(2) The election of officers shall occur at any time at a called meeting of the Board, or by letter ballot, between October 1st and December 1st of the odd years.

(3) If the election is by letter ballot, without a meeting of the Board, the Chairman shall, through the Secretary, give notice of such election prior to October 10th of the odd years, and shall also give notice, at the same time, of the appointment of two tellers in one city, members of the Board, but not officers of the same, to whom the votes shall be mailed. These tellers shall open the ballots on November 1st, and report the result to the Chairman of the Board. If no one has received a majority of the votes cast for either office, the Chairman shall order a new ballot, similar to the first, but limiting the names voted for to the two receiving the highest number of votes for that office on the first ballot. The tellers shall open the second ballot on December 1st, and report as before. The Chairman shall then announce the result of the ballot to all the members, and the new officers shall act from the beginning of the following calendar year.

(4) Vacancies in the offices of the Board may be filled at any time, either by a meeting of the Board or by letter ballot as described in Section 3. In a case of a vacancy occurring, the remaining officer shall discharge the duties of both till the vacancy is duly filled.

Other rules adopted August 3, 1903.

14. That each Society, member of this Association, be credited with 90 per cent. of the receipts from all advertisements sent in to the JOURNAL by said Society until January 1, 1895.

15. That future JOURNALS be issued with cut leaves.

16. That the Constitution be reprinted in portable form, with all subsequent additions, together with report of these proceedings.

17. That the Secretary be requested to see that cuts published with linear scales bear metric scales, unless objection is made by the authors.

Adopted by letter ballot, submitted May 15, 1894.

18. Advertising rates of the JOURNAL increased 50 per cent.

19. Proportion of the net proceeds of advertisements credited to any Society limited to 50 per cent.

20. Number of extra copies of the JOURNAL sent to members of the Board made five.

21. Number of copies of the JOURNAL to be printed, over and above the mailing list, 250.

Adopted by letter ballot, submitted December 18, 1894.

22. Secretary authorized to print advance copies of papers, and send out the same for discussion to all members of the Association indicated to him by the writer, or otherwise, or to such as may request copies, provided the Society in which the paper originates is charged with the extra cost of same.

Adopted by letter ballot, submitted June 20, 1895.

RULES PROPOSED BY THE WESTERN SOCIETY OF ENGINEERS.

23. The object of the JOURNAL is to print the papers and transactions of the Societies, and it is not for the purpose of establishing a professional monthly magazine.

24. The amount of matter must be restricted to that which can be published at a cost of $3 per annum for each person on the mailing list of each Society, except as hereinafter provided.

25. No Society having dues or assessments in arrears for more than ninety days after notice, or whose arrearages shall at any time exceed $2 per member, shall participate in the privileges of the Association; nor shall it be in the power of the Board of Managers to deviate from enforcing this rule.

26. The Association shall not have power to make any contract or incur any liabilities which will bind the Association to an expenditure beyond the limitations specifically permitted by the Articles of Association.

27. The Association shall not publish in the JOURNAL any other matter than the papers and transactions of the Societies, if it shall appear that by so doing the cost will exceed $3 per annum per member of the Societies.

28. The Association may secure subscriptions to the JOURNAL, and furnish reprints, with a view to profit to the Association.

Adopted by letter ballot, submitted October 15, 1897.

29. The issue of five copies of the JOURNAL monthly to each member of the Board of Managers discontinued.

30. The Secretary authorized to send, gratis, to any Society belonging to the Association as many extra copies of any issue of the JOURNAL as it shall notify him it desires, not exceeding five copies for each representative it has on the Board of Managers.

Adopted by letter ballot, submitted September—, 1898.

31. To allow the Society securing same 90 per cent. (based on present rates) of the receipts from new advertisements secured for the JOURNAL.

32. To allow authors of papers appearing in the JOURNAL to append to their names (in addition to "Member of ——— Society") such college degrees and scientific society memberships as they may choose.

33. To allow authors of papers appearing in the JOURNAL to append a statement of their present or past professional position, in addition to "Member of ——— Society."

Adopted by letter ballot, submitted December 5, 1898.

34. All ballots close six weeks after the date of mailing blanks to the members of the Board of Managers.

Adopted by letter ballot, No. 103, submitted November 7, 1901.

35. That the Secretary be authorized to furnish to the author of any paper, at 15 cents each, additional copies of the issue of the JOURNAL containing such paper, provided due notice be given in advance, stating the number of such extra copies required.

(B) RULINGS BY CHAIRMEN.

36. Societies which enter must require all their members to take the JOURNAL. J. B. Johnson, November 24, 1894.

37. "I will consent (for reasons stated) to allow them (the Association of Engineers of Virginia) to decide how many copies of the JOURNAL they wish to take (not less than 25), provided they will be strictly regular in their compliance with the other requirements of the Articles of Association." J. B. Johnson, November 28, 1894.

38. Authorizing the publication in the JOURNAL of lists of members of the several Societies, with their occupations and addresses. George D. Shepardson, December 5, 1898.

39. Providing for a periodical audit of the accounts of the Secretary. George D. Shepardson, December 16, 1899.

INDEX TO ARTICLES OF ASSOCIATION AND RULES.

NOTE.—"A" means Articles of Association. "A I 1" means Articles of Association, Article I, Section 1. "R" means Rule or Rules.

Name .... A I 1
Object .... A I 1
Organization .... A VII
Articles of Association:
  Time of going into effect .... A VII
  Acceptance of —— .... A V 1, VII
  Amendments .... A VI
  Reprinting .... R 16
Rules and By-laws .... A II 1 ...... R 16
Societies:
  Acceptance of Articles of Association .... A V 1, VII
  Concurrence in amendments to Articles of Association .... A VI
  Admission of —— .... A V 1
    Entrance fee .... A V 1, VII
  Representation on Board .... A II 1
  What proportion of members must take JOURNAL .... R 36, 37
  Members, lists of ——, to be published in JOURNAL .... R 38

Officers, list of ——, to be published in JOURNAL....................R 5
Default in payments....................R 25
Selection of papers....................A IV 1
Distribution of JOURNAL to ——....................A IV 2......R 36, 37
Extra copies....................R 20, 29, 30
Assessments ....A IV 2......R 4, 11, 36
(See Commissions on Advertisements.)
Default in payment of ——....................A V 3......R 25
Exclusion of ——....................A V 3......R 25
Withdrawal of ——....................A V 2
Government:
Board of Managers....................A II 1
Composition ....A II 1
Representation of Societies on ——....................A II 1
Members:
Appointment ....A II 1
Powers ....A III 2
Term of office....................A II 1
Copies of JOURNAL to ——....................R 20, 29, 30
Duties....................A II 1, III 2, IV 2, IV 3, V 1
Powers ....A IV 4, V 1, V 3, VI......R 11, 25
Letter ballot....................R 1, 13 (2), (4)
Time of closing ——....................R 34
Officers ....A II 2
Election of ——....................R 13
Tellers ....R 13 (3)
Terms of office....................R 13 (1)
Vacancies ....R 13 (4)
Chairman ....A II 2
Term of office....................R 13 (1), (4)
Duties ....A III 1......R 1, 11, 13 (3), (4)
Annual Report ....A III 1......R 11
Secretary ....A II 2......R 11
Term of office....................R 13 (1), (4)
Qualifications ....A II 2
Appointment and removal....................A III 2
Duties ....A III 2......R 7, 10, 13 (3), (4), 17
Powers ....A III 2......R 12, 22
Compensation ....A III 2......R 10, 12
Tellers ....R 13 (3)
Auditors ....R 30
Accounts ....R 10, 25
Revenue ....A IV 3......R 18, 28, 35
(See, also, Assessments, under Societies.)
Auditing of ——....................A III 1, III 2......R 10, 11, 30
Surplus or deficiency....................A V 2
Moneys:
Custody of ——....................A III 2
Receipts from advertisements....................See JOURNAL
Liabilities, limitation of ——....................R 26
Assessments ....See Societies

JOURNAL:
Character of ——........................A I 1.......R 2. 23
Cost of ——, limitation of ——........................R 24, 27
Time of issuing..R 2
Publication ....A III 2......R 10
Arrangement of material in ——........................ R 2, 3
Papers:
Selection of ——......................A IV 1, III 2......R 9
Custody of ——......................................A III 2
Advance copies of ——....................................R 22
Priority of publication of ——............................R 6
Copying of —— from JOURNAL..............................R 7
Authors' titles and records..........................R 32, 33
Authors, extra copies to ——.............................R 35
Reprints of ——..R 28
Other material ....A III 1, IV 4......R 5, 7, 8, 27
Chairman's annual report..................A III 1......R 11
Lists of officers of Societies............................R 5
Lists of members of Societies............................R 38
Descriptive Index ....R 8
Illustrations ....R 17
Advertisements...A IV 3
Rates of ——...R 18
Commissions on ——..............................R 12, 14, 19, 31
Binding ....R 15
Distribution ....A IV 2, IV 3
Subscriptions ....A IV 3......R 28
Sale...A IV 3
Surplus copies ....R 21
Copies to members of Board...........................R 20, 29
Copies to Societies.......................................R 30
Copies to authors...R 35

ABSTRACTS OF PROCEEDINGS.

FROM MEETING OF REPRESENTATIVES OF THE SOCIETIES.

CHICAGO, DECEMBER 4, 1880,
TO
DECEMBER 31, 1904.

MEETING OF REPRESENTATIVES OF SOCIETIES.

CHICAGO, DECEMBER 4, 1880.

See JOURNAL, Vol. I, No. 1, November, 1881, page 1.

Western Society of Engineers, represented by Benezette Williams, L. P. Morehouse and John W. Weston.

Civil Engineers' Club of Cleveland, represented by M. E. Rawson and A. M. Wellington.

Engineers' Club of St. Louis, represented by Chas. A. Smith.

Boston Society of Civil Engineers, represented by letter.

Benezette Williams, Chairman; A. M. Wellington, Secretary.

Articles of Association adopted.

ABSTRACT OF RECORDS OF MEETINGS OF THE BOARD OF MANAGERS.

CLEVELAND, OHIO, JUNE 11, 1881.

See JOURNAL, Vol. I, No. 1, November, 1881, page 5.

Election of Benezette Williams, Chairman of Board of Managers, confirmed.

M. E. Rawson elected Secretary pro tem.

Resolutions unanimously adopted in favor of independent monthly publication.

Matter submitted by each Society to be placed separately in the pamphlet, under the proper heading; the positions to be arranged in the order of the date of organization. Form of title page adopted

Provision made for decision of questions by letter ballot.

Scale of prices for advertisements adopted.

Between the meeting of June 11, 1881, and the issue of the first number of the JOURNAL (November 1, 1881), the Board completed its organization by the election of H. G. Prout as Secretary, and arranged to have the work of publication carried on under his charge at stipulated rates.

NEW YORK, JUNE 22, 1882.

See first annual report of Chairman, January 2, 1883, published in JOURNAL, Vol. II, No. 3, January, 1883, page 107.

Rule adopted in the manner of levying assessments, by which each assessment is proportioned to the Societies on the basis of the number of copies of the JOURNAL taken at the time the assessment is made.

Address issued "To the Engineers of America." This address is printed in Vol. I, June, 1882, page 289.

New York, September 4, 1884.

See Journal, Vol. III, No. 12, October, 1884, page 329.

Assessment of $3 ordered, to be paid in instalments of $1; each instalment to be based on the mailing list at the time the instalment is called for, and to be subject to the order of the Chairman.

Names and addresses of officers of each Society ordered printed upon the second page of the cover of the Journal.

Resolved, "That in the opinion of this Board it is desirable that papers read before the Societies of this Association should not be published in professional periodicals previous to being published by the Association. That there is no objection to publishing them in whole or in part in local newspapers.

Secretary instructed to insert in the Journal the following: "Editors reprinting articles from this Journal are requested to credit both the Journal and the Society before which such articles were read."

Chairman authorized to arrange for publishing in the Journal an index of engineering reports and Society transactions, and abstracts of such reports and transactions as may be found desirable.

Contract with Atkin & Prout, for printing the Journal, continued.

Chicago, April 15, 16, 1887.

See Journal, Vol. VI, No. 5, May, 1887, page 215.

Proposition from H. G. Prout, Secretary, for printing the Journal, accepted.

Engineers' Club of Kansas City admitted to membership in Association.

Benezette Williams and H. G. Prout unanimously re-elected Chairman and Secretary, respectively.

Ordered that Index Department remain under the general control of J. B. Johnson.

Action taken, looking to the formation of "an organic confederation of engineering societies."

Ordered that the official documents of the Council of Engineering Societies upon National Public Works be published in the Journal.

Assessment authorized.

Chicago, December 3, 4, 1889.

See Journal, Vol. VIII, No. 12, December, 1889, page 589.

Amendments to the Articles of Association adopted, for submission to the Societies; providing:

1. For the submission to the Societies, by the Board, at the request of any Society, "any question of scientific, technical or professional interest," the several Societies to report to the Board, and the Board to formulate and publish, in the Journal, "a general report embodying the facts and in accordance with the general sense and tenor of the local reports."

2. For recommendation to the Societies, by the Board of "recommendations on any subject affecting the policy of the Association or the mutual relations of the participating Societies. Adoption of such recommendations by two-thirds of the Societies to make them 'the law of the Association and binding upon all participating Societies.' "

These amendments were not subsequently ratified by the Societies.

Proposition from John W. Weston, to publish the Journal and perform the duties of the Secretary in consideration of $2.75 per annum from each Society member, and $3 from each outside subscriber, accepted.

Committee appointed "to prepare an address to the various engineering societies of this country on the subject of a national organization."

Benezette Williams unanimously re-elected Chairman.

John W. Weston unanimously elected Secretary.

CHICAGO, SEPTEMBER 11, 1891.

See JOURNAL, Vol. X, No. 10, October, 1891, page 511.

A discussion "on the value and quantity of matter sent to the Secretary for publication" resulted in "the opinion that final control should rest with the Board."

Resolved:

1. That Mr. Weston be requested to continue the publication of the JOURNAL to the close of the current year and volume.

2. That, "beginning with the January number, 1892, a Secretary be employed at a salary not to exceed $600 per annum"; said Secretary to "conduct all the correspondence and other business pertaining to the office" and to publish the JOURNAL at standard current prices."

3. That the Chairman audit all bills and accounts, and collect from each Society quarterly its pro rata of the estimated net cost of the publication, and publish annually in the JOURNAL his report to the Board on this subject.

4. That 50 per cent. commission be allowed to each Society and to the Secretary for advertisements obtained by them for the JOURNAL.

Benezette Williams and John W. Weston re-elected Chairman and Secretary, respectively.

Assessment authorized.

CHICAGO, AUGUST 1, 2, 3, 1893.

See JOURNAL, Vol. XII, No. 7, July, 1893, page 380.

Resignation of Benezette Williams, as Chairman, accepted.

RULES ADOPTED, GOVERNING ELECTION OF OFFICERS.

1. President and Secretary elected for two years each, beginning January 1st of each even year, "but they shall remain in office till their successors are chosen."

2. Election at any called meeting of the Board, or by letter ballot, between October 1st and December 1st of the odd years.

3. If by letter ballot, "the Chairman shall, through the Secretary, give notice of such election prior to October 10th of the odd years," appointing two tellers in one city, members, but not officers, of the Board. Ballots to be opened November 1st and result reported to Chairman. Provision for failure to elect on first ballot.

4. Vacancies may be filled at any time, at a meeting of the Board, or by letter ballot, the remaining officer to discharge the duties of both offices pending the vacancy.

Ordered:

That each Society be allowed 90 per cent. of receipts from its advertisements until January 1, 1895.

That future JOURNALS be issued with cut leaves.

"That the Constitution be reprinted in portable form, with all subsequent additions, together with report of these proceedings."

"That the Secretary be requested to see that cuts published with linear scales bear metric linear scales, unless objection is made by the authors."

Assessment ordered, to cover expenses of members attending meeting.

LETTER BALLOTS OF THE BOARD OF MANAGERS.

Ballot Counted November 1, 1893.

See report for 1893, by Benezette Williams, Retiring Chairman, dated February 6, 1894. Journal, Vol. XIII, No. 1, January, 1894.

J. B. Johnson elected Chairman for 1894-95.

John C. Trautwine, Jr., elected Secretary for 1894-95.

Questions Submitted May 15, 1894.

Results Announced June 1, 1894.

1. Shall the advertising rates of the Journal be increased 50 per cent.?

Yes: Waddell, Benjamin, Appleton, Nichol, Williams, Morris, Russell.

No: Keerl, Manley, Freeman, Tinkham.

Yes, 7; No, 4; doubtful, Pike (not at present). Carried.

2. Shall the proportion of the net proceeds of advertisements credited to any Society be limited to 50 per cent.?

Yes: Russell, Morris, Williams, Nichol, Appleton, Benjamin, Pike, Waddell, Keerl.

No: Tinkham, Freeman, Manley.

Yes, 9; No, 3. Carried.

3. Shall the number of extra copies of the Journal sent to members of the Board be made five?

Yes: Manley, Freeman, Tinkham, Waddell, Pike, Benjamin, Appleton, Nichol, Williams, Morris, Russell.

No: Keerl.

Yes, 11; No, 1. Carried.

4. What number of extra copies of the Journal over and above mailing list shall be printed?

300: Russell, Williams, Waddell, Tinkham, Manley, Freeman.

200: Morris (or 15 per cent.), Appleton, Benjamin.

200 to 300: Nichol.

250: Pike.

250 to 300: Keerl.

Carried, 250.

5. Shall the Board purchase 250 bound copies of the Engineering Index for $375?

Yes: Waddell, Benjamin, Williams, Morris, Russell.

No: Keerl, Freeman, Manley, Tinkham, Pike.

No vote: Appleton, Nichol.

Yes, 5; No, 5. Lost.

Questions Submitted December 18, 1894.

Results Announced January 7, 1895.

1. Shall the December number of the Journal include a reasonable amount of literary matter in addition to the Annual Index Summary?

Yes: Freeman, Manley, Tinkham, Waddell, Nichol, Williams, Johnson, Barnes and Keerl.

No: Appleton, Morris.

Yes, 9; No, 2. Carried.

2. Shall a special assessment be levied, after the expenses for the year 1894 have been determined, to cover such deficit as remains for this year?

Yes: Unanimous. Carried.

3. May individual Societies be admitted to membership in the Association without paying the 50 cents initiation fee for their entire membership, provided this fee be paid by as many as take the JOURNAL, and provided, further, that this number be not less than 25?

Yes: Freeman, Waddell, Nichol and Morris.

No: Manley, Tinkham, Johnson, Appleton, Barnes and Keerl.

Doubtful: Williams.

Yes, 4; No, 6; Doubtful, 1. Lost.

4. Shall the Secretary be authorized to print advance copies of papers and send out the same for discussion to all members of the Association indicated to him by the writer, or otherwise, or to such as may request copies, provided the Society in which the paper originates is charged with the extra cost of same?

Yes: Johnson, Freeman, Manley, Tinkham, Appleton, Barnes and Keerl.

No: Morris.

Doubtful: Waddell, Nichol and Williams.

Yes, 7; No, 1; Doubtful, 3. Carried.

5. Or, shall advance copies of important papers be printed and circulated as indicated in 4, at the expense of the Association?

Yes: Waddell and Barnes.

No: Freeman, Manley, Tinkham, Appleton, Johnson, Morris and Keerl.

Doubtful: Williams. (Nichol does not vote.)

Yes, 2; No, 7; Doubtful, etc., 2. Lost.

6. Shall the Chairman be authorized to try and effect an arrangement whereby the Index Department shall hereafter be conducted by one or more of the national societies?

Yes: Manley, Tinkham and Keerl.

No: Appleton, Johnson, Waddell, Williams, Barnes and Morris.

Doubtful: Freeman. (Nichol does not vote.)

Yes, 3; No, 6; Doubtful, etc., 2. Lost.

7. Is it desirable to arrange for an annual meeting of the members of the Association? . . . . Is it practicable? . . . .

(A) Desirable?

Yes: Tinkham, Appleton, Keerl and Williams.

No: Barnes and Morris.

Doubtful: Waddell and Manley. (Nichol does not vote.)

Yes, 4; No, 2; Doubtful, 2. Lost.

(B) Practicable?

Yes: Keerl.

No: Freeman, Tinkham, Appleton, Williams, Barnes and Morris.

Doubtful: Waddell. (Nichol does not vote.)

Yes, 1; No, 6; Doubtful, etc., 2. Lost.

8. Shall the "Contribution Box" and the "Library," as conducted by our Secretary in the JOURNAL, be discontinued, with an annual saving of about $200?

Yes: Appleton.

No: Freeman, Manley, Tinkham, Waddell, Williams, Barnes, Johnson, Morris and Keerl. (Nichol does not vote.)

Yes, 1; No, 9; (?), 1. Lost.

9. Would you attend a meeting of this Board if appointed to be held in New York City or Philadelphia, on or about January 16th next?

Yes: Freeman, Tinkham and Manley.

No: Appleton, Johnson, Nichol, Williams, Barnes, Morris and Keerl.

Doubtful: Waddell.

Yes, 3; No, 7; Doubtful, 1. Lost.

10. Shall the Index Department of the JOURNAL be discontinued regardless of the action of the national societies on this subject, with a total annual saving, as estimated by the Secretary for 1894, of $900, out of a total cost for 1894 of $5300? (Members might consult their Societies on this subject.)

Yes: Appleton, Nichol and Keerl.

No: Freeman, Tinkham, Waddell, Williams, Johnson and Morris.

Doubtful: Manley. (Barnes does not vote.)

Yes, 3; No, 6; Doubtful, etc., 2. Lost.

Voting, ten members, viz: Messrs. Tinkham, Freeman, Manley, Williams, Nichol, Appleton, Waddell, Johnson, Barnes (St. Louis) and Morris.

QUESTION SUBMITTED JANUARY 3, 1895.

Result Announced ——.

Admission of Association of Engineers of Virginia to membership in the Association of Engineering Societies.

Yes: Keerl, Williams, Barnes, Morris, Tinkham, Manley, Freeman, Benjamin, Pike, Waddell and Nichol.

Yes, 11. Carried.

QUESTION SUBMITTED JANUARY 7, 1895.

Result Announced ——.

Admission of the Denver Society of Civil Engineers to membership in the Association of Engineering Societies.

Yes: Keerl, Williams, Barnes, Tinkham, Manley, Freeman, Benjamin, Waddell, Nichol and Woodman.

No: Appleton.

Yes, 10; No, 1. Carried.

QUESTIONS SUBMITTED MARCH 2, 1895.

Results Announced ——.

1. On the admission of the Technical Society of the Pacific Coast to membership in the Association of Engineering Societies.

Yes: Benjamin, Williams, Pike, Woodman, Keerl, Wason, Barns, Barnes, Johnson, Manley, Tinkham, Freeman, Churchill, Waddell, Nichol, Martin and Appleton.

Yes, 17. Carried.

2. On the acceptance of fifty bound copies of the volume of Index Notes from Mr. Weston, in payment of his indebtedness to the Association to the amount of $72.

Yes: Benjamin, Williams, Pike, Woodman, Keerl, Barns, Barnes, Waddell, Nichol and Appleton.

No: Wason, Manley, Tinkham, Freeman and Martin.

Yes, 10; No, 5. Carried.

3. On authorizing the Chairman and Secretary to decline to publish papers which have already been published either in full, or in very full abstract, in any engineering journal.

No: Williams, Woodman, Keerl, Wason, Barnes, Manley, Tinkham, Freeman, Churchill, Nichol and Waddell.

No, 11. Lost.

QUESTIONS SUBMITTED JUNE 20, 1895.

Results Announced July 11, 1895.

Rules for the government of the Board of Managers, proposed by the Western Society of Engineers, and their adoption moved by the members of the Board from that Society:

(For vote in detail, see below.)

1. The object of the JOURNAL is to print the papers and transactions of the Societies, and it is not for the purpose of establishing a professional monthly magazine.

Yes, 11; No, 4. Carried.

2. The amount of matter must be restricted to that which can be published at a cost of $3 per annum for each person on the mailing list of each Society, except as hereinafter provided.

Yes, 8; No, 7. Carried.

3. The amount of matter which each Society is entitled to have published to be in direct proportion to the amount it contributes to the cost of publication.

No, 15. Lost.

4. Any Society desiring to publish matter in excess of its proportion may publish such matter by paying the full extra cost thereof.

No, 15. Lost.

5. No Society having dues or assessments in arrears for more than ninety days after notice, or whose arrearages shall at any time exceed $2 per member, shall participate in the privileges of the Association; nor shall it be in the power of the Board of Managers to deviate from enforcing this rule.

Yes, 10; No, 6. Carried.

6. A paper shall be accredited to the Society before which it is read, but the author, if a member of any Society or Societies of the Association, shall be credited with such membership, and none other.

Yes, 7; No, 8. Lost.

7. The Association shall not have power to make any contracts or incur any liabilities which will bind the Association to an expenditure beyond the limitations specifically permitted by the Articles of Association.

Yes, 10; No, 5. Carried.

8. The Secretary of the Association shall not have authority to edit any papers sent for publication, except by specific consent of the Society furnishing the paper.

No, 15. Lost.

9. Advertisements may be received by and inserted in the JOURNAL by its management, but all contracts therefor must terminate in the calendar year of the contract.

Yes, 6; No, 10. Lost.

10. The Association shall not publish in the JOURNAL any other matter

than the papers and transactions of the Societies, if it shall appear that by so doing the cost will exceed $3 per annum per member of the Societies.

Yes, 8; No, 7. Carried.

11. The Association may secure subscriptions to the JOURNAL, and furnish reprints, with a view to profit to the Association.

Yes, 12; No, 4. Carried.

12. The Western Society has also passed the following resolution:

"*Resolved*, That the Board of Managers of the Association of Engineering Societies be requested to make to this Society a financial statement for the first quarter of the present year, and for each quarter thereafter, showing the cost of the JOURNAL, the number of members in each Society on the JOURNAL mailing list, the amount of money paid (to the Association) by each Society and the amount any Society is delinquent."

The members will please observe that this is a request made to the Board, and is not a part of the rules of the Board whose adoption has been moved and are given above. The Chairman will take the liberty of reminding the members of the Board that the preparation of a quarterly financial statement involves a very considerable amount of additional work on the part of our Secretary, and perhaps more than he can afford to give for the salary paid. You will please indicate your vote, also, on this request, as to whether or not it shall become a rule of the Board.

(Note, signed by Benezette Williams, Member, Board of Managers.)

Yes, 1; No, 15. Lost.

VOTE ON TWELVE QUESTIONS, AS ABOVE.

		QUESTION NO.											
Society.	Member of Board.	1	2	3	4	5	6	7	8	9	10	11	12
Western	Williams,			N	N	Y	Y	N	N	N		Y	N
	Barnes,	Y	N	N	N	Y	N	Y	N	N	Y	Y	Y
	Nichol,	Y	Y			Y	Y	Y		Y	Y	Y	N
Boston	Brooks,	N	N	N	N	N	N	N	N	N	N	N	N
	Manley,	N	Y	N	N	N	N	N	N	N	N	N	N
	Tinkham,	Y	N	N	N	Y	N	Y	N	N	N	Y	N
	Freeman,	N	N	N	N	N	N	N	N	N	N	N	N
Cleveland	Ritchie,	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	N
St. Louis	Johnson,	Y	N	N	N	Y	N	Y	N	N	N	Y	N
	Barns,	Y	Y	N	N	N	N	Y	N	N	Y	Y	N
St. Paul	Woodman,	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	N
Minneapolis	Pike,	Y	Y	N	N	N			N	N	Y	Y	N
Kansas City	Waddell,	Y	N	N	N	Y	Y	Y	N	Y	N	Y	N
Montana	Keerl,	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	N
Pacific Coast	Hasson,	N	N	N	N	N	N	N	N	N	N	N	N
Virginia	Churchill,	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	N
Denver													
Totals:	Yes,	11	8			10	7	10		6	8	12	1
	No,	4	7	15	15	6	8	5	15	10	7	4	15

QUESTION SUBMITTED OCTOBER 17, 1895.

Result Announced November 11, 1895.

Nominations for officers for 1896-97:

For Chairman—S. E. Tinkham, nominated by Fred Brooks, John R. Freeman and Henry Manley.

James Ritchie, nominated by the Civil Engineers' Club of Cleveland.

J. B. Johnson, nominated by James Ritchie and James S. Keerl. Nomination declined.

For Secretary—John C. Trautwine, Jr., Nominated by Fred Brooks, John R. Freeman, Henry Manley, James Ritchie, James S. Keerl and the Civil Engineers' Club of Cleveland.

The vote:

For Chairman—S. E. Tinkham, 9 votes; James Ritchie, 3 votes.

For Secretary—John C. Trautwine, Jr., 12 votes.

Tellers—Prof. J. P. Johnson and Mr. W. E. Barns, of the Engineers' Club of St. Louis.

Questions Submitted December 2, 1895.

Results Announced ——.

1. Shall the price of the Journal hereafter be changed to subscribers?

2. Shall Mr. John R. Dunlap, Editor of the *Engineering Magazine*, be given permission to republish, in book form, the Index Notes which have appeared in the Journal for the last four years, or since the previous bound Index Summary appeared?

No record of vote on these questions.

Question Submitted January 1, 1897.

Result Announced ——.

On the admission of the Detroit Engineering Society to membership in the Association of Engineering Societies.

Yes: Hermann, Hasson, Manley, Brooks, Freeman, Tinkham, Culley, Churchill, Johnson, Hyde, Woodman, Campbell, Vischer, Shepardson and Keerl.

Yes, 15. Carried.

Questions Submitted October 15, 1897.

Results Announced November 11, 1897.

1. Nominations for officers for 1898-99:

For Chairman—Fred Brooks, of Boston, nominated by John W. Langley, member of the Civil Engineers' Club of Cleveland.

George D. Shepardson, of Minneapolis, nominated by Edwin E. Woodman, of the Civil Engineers' Society of St. Paul.

For Secretary—John C. Trautwine, Jr., nominated by Messrs. Langley and Woodman.

Tellers—Messrs. Henry Manley and John R. Freeman, of the Boston Society of Civil Engineers.

2. That the issue of five copies of the Journal monthly to each member of the Board of Managers be discontinued.

Moved by Mr. Edwin E. Woodman, member of the Board for the Civil Engineers' Society of St. Paul.

3. That the Secretary be authorized to send, gratis, to any Society belonging to the Association, as many extra copies of any issue of the Journal as it shall notify him it desires not exceeding five copies for each representative it has on the Board of Managers.

Moved by Mr. S. E. Tinkham, Chairman.

4. On the advisability of reducing the amount of the fourth quarterly assessment, for the year 1897, from 75 cents (as usual) to 25 cents.

THE VOTE.

QUESTION 1—For Chairman:

Whole number of ballots	14
Informal	1
	13
Necessary for a choice	7
Prof. George D. Shepardson has	8
Mr. Fred Brooks has	5

For Secretary:

Whole number of ballots	14
Mr. John C. Trautwine, Jr., has	14

QUESTIONS 2, 3, and 4:

Whole number of votes received	14
One ballot was not signed	1
Total number of votes counted	13

On Question 2, 9 votes were in the affirmative and 4 in the negative.

On both Questions 3 and 4, the vote was unanimously in the affirmative.

The unsigned ballot was in the affirmative on all the questions, so the result would not be changed if it were counted.

QUESTION SUBMITTED JANUARY 15, 1898.

Result Announced March 29, 1898.

Admission of the Engineers' Society of Western New York to membership in the Association of Engineering Societies.

Yes: Brooks, Wilson, Churchill, Tinkham, Woodman, Hyde, Freeman, Keerl, Johnson, Henny, Jones, Manley and Livingston.

Yes, 13. Carried.

January 15, 1898, Chairman Shepardson wrote: "About the proportion of the membership in each Society that must be assessed and to which the JOURNAL is sent: In a few cases only a part of the membership has been assessed, to make it possible for certain Societies to join or to retain membership. Do you wish to lay down a rigid interpretation of the rule or to leave it to the discretion of the Board in special cases?"

Mr. John R. Freeman replies: "I favor a liberal interpretation of the rule, and would leave any special case to the discretion of the Board."

QUESTIONS SUBMITTED SEPTEMBER —, 1898.

Results Announced December 5, 1898.

1. To allow the Society securing same, 90 per cent. (based on present rates) of the receipts from new advertisements secured for the JOURNAL.

Yes: Brackett, Johnson, Thacher, Woodman, Shepardson, Tinkham, Howe, Brooks, von Geldern, Tutton and Manley.

No: Henny, Freeman and Churchill.

Yes, 11; No, 3. Carried.

2. To allow authors of papers appearing in the JOURNAL to append to their names (in addition to "Member of ——— Society") such college degrees and scientific society memberships as they may choose.

Yes: Henny, Johnson, Freeman, Thacher, Woodman, Howe, Brooks, von Geldern and Tutton.

No: Brackett, Churchill, Shepardson, Tinkham and Manley.

Yes, 9; No, 5. Carried.

3. To allow authors of papers appearing in the JOURNAL to append a statement of their present or past professional position in addition to "Member of ——— Society."

Yes: Henny, Freeman, Woodman, Shepardson, Howe, Brooks, von Geldern, Tutton and Manley.

No: Brackett, Johnson, Churchill, Thacher and Tinkham.

Yes, 9; No, 5. Carried.

4. To hold Secretaries of local Societies responsible for the accuracy of titles, society memberships and professional positions of authors of papers sent for publication in the JOURNAL.

Yes: Henny, Johnson, Freeman and Shepardson.

No: Brackett, Churchill, Thacher, Woodman, Tinkham, Howe, Brooks, Tutton and Manley.

Yes, 4; No, 9. Lost.

5. To have the Secretary prepare brief sketches of authors of papers in the JOURNAL.

Yes: Freeman, Shepardson and Howe.

No: Henny, Brackett, Johnson, Churchill, Thacher, Woodman, Tinkham, Brooks, von Geldern, Tutton and Manley.

Yes, 3; No, 11. Lost.

QUESTION SUBMITTED SEPTEMBER —, 1898.

Result Announced, September 10, 1898.

Admission of the Louisiana Engineering Society to membership in the Association of Engineering Societies.

Yes: Henny, Brackett, Johnson, Manley, Tutton, von Geldern Brooks, Howe, Tinkham, Freeman, Woodman, Shepardson, Churchill and Thacher.

Yes, 14. Carried.

QUESTIONS SUBMITTED DECEMBER 5, 1898.

Results Announced ——.

1. Admission of the Engineers' Club of Cincinnati to membership in the Association of Engineering Societies.

Yes: Johnson, Coleman, von Geldern, Henny, Ritchie, Freeman, Brooks, Thacher, Woodman, Tutton, Tinkham, Churchill, Brackett, Howe, Manley and Shepardson.

Yes, 16. Carried.

2. All ballots close six weeks after the date of mailing blanks to the members of the Board of Managers.

Yes: von Geldern, Johnson, Shepardson, Manley, Churchill, Howe, Brackett, Tinkham, Tutton, Woodman, Thacher, Brooks, Ritchie, Freeman, Coleman and Henny.

Yes, 16. Carried.

QUESTION SUBMITTED NOVEMBER 28, 1899.

Result Announced January 3, 1900.

Election of officers for 1900-1901:

For Chairman—James Ritchie, of the Civil Engineers' Club of Cleveland, 12 votes.

S. E. Tinkham, of Boston Society of Civil Engineers, 1 vote.

George D. Shepardson, of Civil Engineers' Society of St. Paul, 1 vote.

For Secretary—John C. Trautwine, Jr., 15 votes.

Tellers—Messrs. Frank C. Osborn and James Ritchie, of the Civil Engineers' Club of Cleveland, Ohio.

QUESTION SUBMITTED JANUARY 11, 1901.

Ballot No. 101.

Result Announced ——.

Donate, to the Duplicate Technical Library of the University of Wisconsin, one copy of each number of the JOURNAL, of which the list shows more than fifty copies on hand.

Yes: Osborn, Harper, Brooks, Brackett, Freeman, von Geldern, Freeman, Ritchie, Tutton, Layman and Tinkham.

No: Henny.

Yes, 12; No, 1. Carried.

QUESTIONS SUBMITTED NOVEMBER 7, 1901.

Ballots Nos. 102, 103 and 104.

Results Announced December 27, 1901.

Ballot No. 102. That the Secretary be instructed to prepare an index of the material contained in the first twenty-five volumes of the JOURNAL of the Association, ending with December, 1900, and to have said index printed, bound in paper and distributed to the members of our Societies and to our subscribers, exchanges and advertisers, and that the Secretary be authorized to make such arrangements as he can for the procuring of advertisements in such index, in order to cover all or a part of the cost.

Moved by Mr. S. E. Tinkham, of the Boston Society of Civil Engineers.

Yes, 17. Carried.

Ballot No. 103. That the Secretary be authorized to furnish, to the author of any paper, at 15 cents each, additional copies of the issue of the JOURNAL containing such paper, provided due notice be given in advance, stating the number of such extra copies required.

Moved by Mr. S. E. Tinkham, of the Boston Society of Civil Engineers.

Yes, 17. Carried.

Ballot No. 104. That, from and after January 1, 1902, the Secretary shall receive, in each year, as salary, 75 cents for each member of the societies forming the Association at the close of the preceding year.

Moved by Mr. Charles H. Tutton, of the Engineers' Society of Western New York.

Yes, 10; No, 7. Lost, for want of two-thirds vote, required by Articles of Association.

QUESTION SUBMITTED NOVEMBER 7, 1901.

Result Announced January 9, 1902.

Election of officers for 1902-1903:

For Chairman—James Ritchie, Civil Engineers' Club of Cleveland, 11 votes.

Gardner S. Williams, Detroit Engineering Society, 3 votes.

A. O. Powell, Civil Engineers' Society of St. Paul, 1 vote.

For Secretary—John C. Trautwine, Jr., 15 votes.

Tellers—Messrs. W. A. Layman and S. E. Freeman (?) of the Engineers' Club of St. Louis.

QUESTION SUBMITTED NOVEMBER 23, 1901.

Ballot No. 105.

Result Announced January 4, 1902.

Authorize the Secretary to donate, to the Department of Mining and Metallurgy, McGill University, Montreal, one copy of each number of the JOURNAL, of which the list shows more than fifty copies on hand.

Yes: Tinkham, Freeman (John R.), Manley, Brooks, Brackett, Hopkinson, Ritchie, Hoag, Harper, Layman, Freeman (S. E.), Wilson, Henny, von Geldern and Malochee.

No: Tutton.

Yes, 15; No, 1. Carried.

QUESTION SUBMITTED SEPTEMBER 18, 1903.

Result Announced November 9, 1903.

Election of officers for 1904-1905:

Nominations:

For Chairman—Dexter Brackett, of the Boson Society of Civil Engineers.

For Secretary—John C. Trautwine, Jr.

The vote:

For Chairman—Mr. Brackett received 13 votes.

For Secretary—Mr. Trautwine received 14 votes.

Tellers—Messrs. Dexter Brackett and Dwight Porter, of the Boston Society of Civil Engineers.

Mr. Brackett having been nominated for the Chairmanship after accepting the appointment as teller, asked Mr. Porter to act for him.

QUESTION SUBMITTED DECEMBER 31, 1903.

Result Announced January 11, 1904.

Admission of the Toledo Society of Engineers to membership in the Association of Engineering Societies.

Yes: von Geldern, Porter, Williams, Freeman, Benjamin, Brackett, Hoffmann, Redfield, Wilson, Tinkham, Théard, Bausch, Haven, Henny, Manley, Toensfeldt and Barker.

Yes, 17. Carried.

RULINGS, ETC., BY CHAIRMEN.

November 24, 1894. J. B. Johnson. Societies which enter must require all their members to take the JOURNAL.

November 28, 1894. J. B. Johnson. Allowing the Association of Engineers of Virginia to subscribe for less than its full membership. (Reconsideration of ruling of November 24th.)

December 5, 1898. George D. Shepardson. Authorizing the publication, in the JOURNAL, of lists of members of the several Societies, with their occupations and addresses.

December 16, 1899. George D. Shepardson. Providing for a periodical audit of the accounts of the Secretary.

February 20, 1901. James Ritchie. Approving the action of the Secretary in agreeing, with *Engineering Magazine*, to maintain the price of Vol. I of the Descriptive Index at $5 per copy, with a special price of $4 to members of the Societies in the Association.

June 14, 1901. James Ritchie. Letter of request to the Secretaries of the Societies:

DEAR SIR,—I desire to call the attention of the Secretaries of our several Societies to the matter of publication of papers in other journals or periodicals prior to their appearance in the JOURNAL of the Association.

Instances of such prior publication have recently come to my notice, and I would request that, so far as possible, the Societies give the Association the advantage of first publication of any papers submitted.

March 26, 1902. James Ritchie. Authorizing the Secretary to donate, to the State Library of New Hampshire, at the request of the Boston Society of Civil Engineers, one copy of each number of the JOURNAL, of which the list shows more than fifty copies on hand.

OFFICERS OF THE BOARD OF MANAGERS FROM ITS ORGANIZATION, IN 1881, TO DECEMBER 31, 1903.

CHAIRMEN.	SOCIETIES.	FIRST ELECTED.
Benezette Williams.	Western Society of Engineers.	June 11, 1881.
J. B. Johnson.	Engineers' Club of St. Louis.	Nov. 1, 1903.
S. E. Tinkham.	Boston Society of Civil Engineers.	Nov. 11, 1895.
George D. Shepardson.	Civil Engineers' Society of St. Paul.	Nov. 11, 1897.
James Ritchie.	Civil Engineers' Club of Cleveland.	Jan. 3, 1900.
Dexter Brackett.	Boston Society of Civil Engineers.	Nov. 9, 1903.

SECRETARIES.	SOCIETIES.	FIRST ELECTED.
Henry G. Prout.	....	Between June 11 and Nov. 1, 1881.
John W. Weston.	Western Society of Engineers.	Dec. 4, 1889.
John C. Trautwine, Jr.	....	Nov. 1, 1893.

Annual Report of the Chairman of the Board of Managers.

CLEVELAND, OHIO, December 31, 1903.

To the Board of Managers of the Association of Engineering Societies.

GENTLEMEN:—I have the honor to present to you my report for the year 1903, and to transmit therewith the report of the Secretary for the same period.

The latter document shows not only an increase in the cost of the JOURNAL, due to continued advances in the printers' rates, but also a decrease in the amount of matter published.

For the former state of affairs there is probably no remedy in sight while business continues fairly active; but it is much to be hoped that the members of our Societies will see the propriety of taking advantage of the excellent facilities, presented by our JOURNAL, for the wide circulation of their papers, in excellent shape, and before an appreciative and extended circle of readers.

We have recently been gratified to receive an application for membership in the Association of Engineering Societies from the Toledo Society of Engineers, and this application is now being sent to you for letter ballot.

I desire to call attention of the members to the statement of assets and liabilities, showing a very satisfactory condition of the Association. We certainly have good reason to be well satisfied with the careful and painstaking manner in which the Secretary has handled the affairs of the Association, and I trust that the Association will this year show its appreciation of his care by allowing him a proper recompense for his services. The entire responsibility for the affairs of the Association rests upon him, and the nominal compensation which he receives is not by any means adequate.

I desire to extend to the new Chairman my best wishes for his success in the administration of his office, and I trust that he will have the same pleasant relations with the Secretary and the members as I have had in the past.

In conclusion, I wish to thank the members and the Secretary for their uniform courtesy to me during the past and to request the same for my successor.

With best wishes for the success of the Association and its members,

Very respectfully,

JAMES RITCHIE, *Chairman.*

Annual Report of the Secretary of the Board of Managers.

PHILADELPHIA, December 31, 1903.

Mr. James Ritchie, Chairman,

413 Chamber of Commerce, Cleveland, Ohio.

DEAR SIR:—I have the honor to present the following report upon the operations of the Secretary's office during the year 1903, and of the condition of the affairs of the Association at the present time.

These data are concisely stated in the following statistical appendixes:

A. Statement of receipts and expenditures during 1903.

B. Estimate of assets and liabilities at the close of 1903.

C. Detailed statement of cost of JOURNAL during 1903, by months.

D. Net cost of JOURNAL during 1903.

E. Statement of material in JOURNAL during 1903, by pages.

F. Comparison of mailing lists of the JOURNAL at the close of 1902 and of 1903, respectively.

G. Comparison of conditions, 1894 to 1903, inclusive.

H. Comparison of conditions, 1901, 1902, 1903.

J. Abstract of minutes of Board of Managers.

Repeated and sharp advances in printers' rates have brought about an increase in all the columns of Appendix H which refer to the cost of the JOURNAL. Notwithstanding this, our cash balance and our estimated net assets, at the close of 1903, are but slightly less than at the close of 1902, although the annual assessment of $2 per member, established in 1898, has been maintained. This is the lowest rate of assessment thus far reached, except that, in 1899, the surplus in the treasury permitted a special rebate of $1 per member, bringing the actual net assessment, for that year, to $1 per member.

I call your attention especially to the marked and gratifying extent to which some of the Societies have taken advantage of the arrangement whereby the Association allows, to its Societies, a commission of 90 per cent. upon all advertisements obtained by them for the Association JOURNAL, thus practically printing the advertisements for the Societies at cost, and leaving, to the Societies, the net receipts from their insertion.

The Engineers' Society of Western New York earns, in this way, an amount practically equal to its annual assessments, and the Boston Society has greatly increased its activity in this direction during the year just closed.

Thus far, however, only a beginning has been made in this direction: and our JOURNAL still remains far from earning, in this way, the sums to which its value, as an advertising medium, entitles it.

The exchange of advertisements, between the JOURNAL and a number of the best engineering periodicals, has been continued.

During the year 1903, thirty-four papers, as follows, were published in the Association JOURNAL:

BOSTON SOCIETY OF CIVIL ENGINEERS.

"Foundation for Coal Pocket at Lincoln Wharf, Boston Elevated Railway Company," by Robert B. Davis. March.

"A Comparison of Three Methods of Estimating Quantities of Soil Stripping from Water-Supply Reservoirs," by Frank S. Hart. April.

"Method of Estimating Quantities of Soil Excavation from Wachusett Reservoir," by Chas. A. Bowman. April.

"Boston Foundations," by Joseph R. Worcester. June.

"Foundations," by George B. Francis. June.

"The Failure of a Sea Wall and Its Reconstruction," by Clarence T. Fernald. June.

"Foundations for the Elevated Structure of the Boston Elevated Railway," by George A. Kimball. June.

"Early and Curious Types of the Cantilever Bridge in New England and New Brunswick," by Alfred W. Parker. July.

"Action of Sea Worms on Foundations in Boston Harbor," by F. W. Hodgdon. August.

"Rainfall and Run-off of New England, Atlantic Coast and Southwestern Colorado Streams," by William O. Webber. November.

Civil Engineers' Club of Cleveland.

"Electric Railway Bridges," by Wilbur J. Watson. January.

"The Burning of Pulverized Coal," by C. O. Bartlett. July.

"The Cost of Open-Hearth Steel as Affected by Using Blast-Furnace Gas in Gas Engines, and Remarks on the Latest Improvements," by Peter Eyermann. September.

Engineers' Club of Minneapolis.

"The Theory of Operation of the Gasoline Engine," by E. C. Oliver. February.

"Red River Valley Drainage Ditches," by Prof. W. R. Hoag. April.

Montana Society of Engineers.

"Annual Address," by Joseph H. Harper. May.

Engineers' Club of St. Louis.

"Electric Shop Drive." Discussion. January.

"On the Use of Beaumont Oil as Fuel," by Henry H. Humphrey. March.

"St. Louis Water Supply," by R. E. McMath. May.

"A Century's Progress in Engineering Education in the United States," by Robert Heywood Fernald. July.

"Reduction of Grade on Railroads," by C. D. Purdon. July.

"The Heyland Induction Motor," by A. S. Langsdorf. September.

"The Physical Structure of Metals and Alloys," by J. J. Kessler, Jr. December.

Technical Society of the Pacific Coast.

"Rainfall on the Pacific Coast of North and South America and the Factors of Water Supply in California," by Marsden Manson. March.

"Personal Experiences in the Construction of a Landing Pier for the Ocos Railway, Guatemala, Central America," by Charles List. March.

"Concrete-Metal Construction," by Emile Villet. October.

"Patent Laws. Are They any Longer Necessary to Progress in Mechanic Arts?" by Geo. W. Dickie. December.

"Patent Law Administration," by John Richards. December.

Detroit Engineering Society.

"Detroit Sewer System," by W. C. King. January.

ENGINEERS' SOCIETY OF WESTERN NEW YORK.

"Abatement of the Smoke Nuisance." Report of Smoke-Abatement Committee. January.

"The Metric System," by C. H. Tutton. February.

"Good Roads," by George C. Diehl. October.

LOUISIANA ENGINEERING SOCIETY.

"Goldschmidt Method of Metallurgy and High Temperature Production by Means of Thermite," by B. Palmer Caldwell. August.

"Gas," by Thomas D. Miller. October.

The abstract of minutes of the Board of Managers, including the original meeting of representatives of the Societies, held in Chicago, December 4, 1880, and extending to the present date inclusive, and the digest of Rules, following the Articles of Association, have been compiled from such data as are available to the Secretary, and it is hardly to be hoped that they are complete. Indeed, certain gaps are indicated in the record. The undersigned will be greatly obliged for any suggestions looking to the improvement of these records.

Respectfully submitted,

JOHN C. TRAUTWINE, JR., *Secretary.*

APPENDIX A.

Statement of Receipts and Expenditures during 1903.

CASH, 1903.

Dr.

To Cash Balance, January 1, 1903		$1,608.68	
" Assessments, at $2.00 per member:			
Boston Society of Civil Engineers	$1,030.50		
Civil Engineers' Club of Cleveland	569.00		
Engineers' Club of St. Louis	339.50		
Civil Engineers' Society of St. Paul	60.00		
Engineers' Club of Minneapolis	186.50		
Montana Society of Engineers	241.00		
Technical Society of the Pacific Coast	301.00		
Detroit Engineering Society	161.00		
Engineers' Society of Western New York	93.50		
Louisiana Engineering Society	125.00		
		3,107.00	
To Initiation Fee, Toledo Society of Engineers		27.00	
" Subscriptions		641.56	
" Sales of Journal		157.62	
" " " Descriptive Index		20.00	
" " " Reprints		44.25	
" " " Periodicals		16.60	
" Advertisements		377.00	
" Advance proofs of paper, etc.		10.00	
" Interest on deposits		43.82	
			$6,053.53

Cr.

By Patterson & White Co. (Printers)		$2,875.94	
" Illustrations		680.24	
" Secretary's salary		600.00	
" Commissions on subscriptions		33.00	
" " " sales		19.95	
" " " advertisements:			
Boston Society of Civil Engineers	$216.00		
Civil Engineers' Club of Cleveland	16.20		
Engineers' Club of St. Louis	36.00		
		268.20	
" Telephone service, two years		20.00	
" Binding Volumes XXVIII and XXIX		2.00	
" Messenger service		2.24	
" Telegrams		6.14	
" Express charges		3.43	
" Postage stamps		34.55	
" Stationery		10.58	
" Mimeographing		1.65	
			$4,557.92
" Cash Balance, December 31, 1903:			
Provident Life and Trust Co.	$1,475.47		
Cash on hand	20.14		
			1,495.61
			$6,053.53

APPENDIX B.

Estimate of Assets and Liabilities at the Close of 1903.

AVAILABLE ASSETS.

Cash Balance, December 31, 1903		$1,495.61	
Less subscriptions for 1904, paid during 1903		63.00	
			$1,432.61
Amounts receivable from Societies (for assessments, advertisements, etc.):			
Boston Society of Civil Engineers	$489.00		
Civil Engineers' Club of Cleveland	158.40		
Engineers' Club of St. Louis	152.50		
Civil Engineers' Society of St. Paul	10.50		
Montana Society of Engineers	61.25		
Technical Society of the Pacific Coast	3.50		
Detroit Engineering Society	57.50		
Engineers' Society of Western New York	273.00		
Louisiana Engineering Society	34.50		
		$1,240.15	
Subscriptions due:			
For 1903	$75.00		
" 1902	12.00		
" 1901 and earlier	219.00		
		306.00	
For reprints		122.92	
" advertisements (other than through Societies)		371.33	
" sales of JOURNAL		23.05	
			2,063.45
			$3,496.06

LIABILITIES.

Patterson & White Co. (Printers):			
For December JOURNAL	$221.99		
" reprints	46.58		
		$268.57	
Commissions on advertisements:			
Boston Society of Civil Engineers	$440.10		
Civil Engineers' Club of Cleveland	61.20		
Engineers' Club of St. Louis	36.00		
Engineers' Society of Western New York	176.40		
A. E. Story, advertising agent	25.00		
		738.70	
Illustrations		12.25	
			1,019.52
Net assets			$2,476.54

APPENDIX C.

Detailed Statement of Gross Cost of Journal during 1903, by Months.

	1	2	3	4	5	6	7	8	9	10	11	12	13
	Composition.	Paper, Presswork, Binding.	Wrapping, etc	Postage.	Printer, Sum of 1, 2, 3 and 4.	Illustrations.*	Cost of Manufact'e Sum of 1, 2, 6.	Wrappers.	Sec'y's Salary.	Sundries.†	Total, Sum of 5, 6, 8, 9, 10.	No. of Pages.‡	Cost per Page.‡
January	$249 70	$221 25	$8 42	$17 16	$496 53	$38 25	$509 20	$4 75	$50 00	$28 28	$617 81	182	$3 39
February	45 23	66 25	4 35	6 61	122 44	6 60	118 08	4 75	50 00	12 23	196 02	60	3 27
March	67 55	105 00	7 62	10 43	190 60	140 70	319 31	4 75	50 00	7 25	399 36	80	4 99
April	59 53	98 90	5 09	8 50	172 02	58 28	216 71	4 75	50 00	31 98	317 03	74	4 28
May	104 85	148 25	6 07	14 04	273 21	3 36	256 46	4 75	50 00	8 15	339 47	118	2 88
June	105 84	150 14	4 40	14 66	275 04	288 26	544 24	4 96	50 00	9 20	627 46	118	5 32
July	68 75	78 40	4 38	8 36	159 89	70 90	218 05	4 75	50 00	6 18	291 72	70	4 17
August	21 40	47 75	4 91	5 39	79 45	50 88	120 03	4 75	50 00	11 03	196 11	36	5 45
September	36 21	76 75	5 81	5 67	124 44	33 58	146 54	4 75	50 00	3 45	216 22	48	4 55
October	67 61	99 75	4 81	8 01	180 18	36 75	204 11	4 75	50 00	7 94	279 62	70	3 99
November	138 63	112 75	5 33	8 20	264 91	15 10	266 48	4 75	50 00	2 87	337 63	78	4 33
December	80 84	110 00	5 68	8 22	204 74	24 75	215 59	4 75	50 00	30 55	314 79	72	4 55
Totals and averages	$1,046 14	$1,315 19	$66 87	$115 25	$2,543 45	$773 47	$3,134 80	$57 21	$600 00	$159 11	$4,133 24	1,006	$4 11

* The figures in column 6 (Illustrations) include preparation of cuts and lithographic stones, and paper and presswork on insets.

† The figures in column 10 (Sundries) include all expenditures of the Association (such as stationery, postage, circulars, etc.) chargeable to the Journal and not embraced in any other column. They do not include the cost of preparing reprints of papers.

‡ The figures in columns 12 (No. of Pages) and 13 (Cost per Page) include 4 cover pages in each number, and 16 pages in indexes to Vols. XXX and XXXI.

APPENDIX D.

Net Cost of Journal, 1903.

Gross cost, as per Appendix C			$4,133.24
Paid for reprints		*$92.04	
Received from sales of reprints		44.25	
			†47.79
			$4,181.03
Deduct receipts, as below, as per Appendix A:			
From subscriptions	$641.56		
Less commissions	33.00		
		$608.56	
From sales of Journals	$157.62		
" " " Descriptive Index	20.00		
	$177.62		
Less commissions	19.95		
		157.67	
From sales of periodicals		16.60	
" advertisements	$377.00		
Less commissions	268.20		
		108.80	
From interest on deposits		43.82	
			935.45
Net cost of Journal, 1903			$3,245.58

APPENDIX E.

Statement of Material in Journal during 1903, by Pages.

	Papers.	Proceedings.	Chairman's Report, etc.	Advertisements.	Indexes to Vols.	List of Members.	Totals.	Cuts.	Plates and Full-Page Cuts.
January	46	14	14	17	. .	87	178	6	2
February	34	6	. .	16	. .	. .	56	5	. .
March	44	16	. .	16	. .	. .	76	18	7
April	52	2	. .	16	. .	. .	70	8	6
May	94	4	. .	16	. .	. .	114	5	. .
June	82	8	. .	16	8	. .	114	6	26
July	48	2	. .	16	. .	. .	66	5	7
August	14	2	. .	16	. .	. .	32	2	5
September	26	2	. .	16	. .	. .	44	8	1
October	42	6	. .	18	. .	. .	66	6	7
November	54	2	. .	18	. .	.	74	1	1
December	32	10	. .	18	8	. .	68	8	1
Totals	568	74	14	199	16	87	958	78	63
Covers							48		
Total.							1006		

*Compiled from printers' bills for 1903.

†Several considerable bills for reprints remaining due the Association at the close of 1903, the payments on that account, during 1903, have exceeded the receipts during the same period.

APPENDIX F.

Comparison of the mailing lists of the JOURNAL, at the close of 1902 and 1903, respectively:

	1902.	1903.	Increase.	Decrease.
Boston Society of Civil Engineers	513	520	7	..
Civil Engineers' Club of Cleveland	233	216	..	17
Engineers' Club of St. Louis	215	225	10	..
Civil Engineers' Society of St. Paul	25	21	..	4
Engineers' Club of Minneapolis	61	86	25	..
Montana Society of Engineers	118	109	..	9
Technical Society of the Pacific Coast	150	154	4	..
Detroit Engineering Society	106	122	16	..
Engineers' Society of Western New York	65	68	3	..
Louisiana Engineering Society	58	67	9	..
In the Societies composing the Association	1544	1588	74	30
Net Increase.....**44**				
Extra copies to Societies	52	41	..	11
Advertisers	20	34	14	..
Exchanges	133	131	..	2
Subscribers	220	222	2	..
Complimentary copies	1	..	..	..
	1970	2016	90	43

Besides this, many copies have been sold and specimen pages sent out, and authors of papers have each received five copies of the JOURNAL containing them. In all, 2300 copies of the May number were printed, 2350 of June and 2250 of each of the other months.

APPENDIX G.

COMPARISON OF CONDITIONS, 1894 TO 1903, INCLUSIVE.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
							Pages of Papers.		Gross Cost of JOURNAL.*					Illustrations.			
Year.	Number of Societies in Association, Dec. 31.	Number of Names on Mail Lists of Societies, Dec. 31.	Subscribers, Dec. 31.	Exchanges, Dec. 31.	Net Receipts from Advertisements.	Total Number of Pages in JOURNAL.	Total.	Per 1000 Members on Mail List.	Total.	Per Page.	Per Member.	Per Member per 1000 Pages.	Annual Assessment per Member.	Small Cuts.	Plates and Full-Page Cuts.	Cost.	Net Assets, Dec. 31.
1894	8	1174	176	110	$671 00	1290	653	556	$5774 59	$4 48	$4 92	$3 81	$3 00	86	54	$651 60	—$758 91‡
1895	11	1477	215	122	599 09	1482	792	536	5911 48	3 99	4 00	2 70	3 66	116	66	859 60	223 93
1896	9	1106	241	108	763 25	856	490	443	3928 42	4 59	3 55	4 15	3 00	62	56	771 39	1244 94
1897	10	1252	233	102	410 25	1016	638	510	3140 43	3 09	2 51	2 47	2 50	57	45	503 85	2562 04
1898	12	1370	246	114	465 58	1110	738	539	3462 08	3 12	2 53	2 28	2 00	166	42	729 38	2936 71
1899	11	1475	249	115	390 88	958	544	369	3233 44	3 38	2 19	2 29	2 00†	124	30	561 24	2442 70†
1900	11	1541	216	116	370 83	1130	666	432	4351 53	3 85	2 82	2 50	2 00	112	27	590 82	2162 67
1901	11	1597	224	115	244 10§	1074	646	405	4856 64	4 52	3 04	2 83	2 00	213	55	1160 90	2062 72
1902	11	1544	220	135	260 60	1030	610	395	3927 01	3 81	2 54	2 36	2 00	172	20	442 43	2601 19
1903	10	1588	222	131	108 80	1006	568	358	4133 24	4 11	2 60	2 58	2 00	78	63	773 47	2476 54

* The publication of the Descriptive Index of Current Technical Literature was discontinued at the end of 1895.

† During 1899, with an assessment of $2.00 per member, the Association made a rebate of $1.00 per member for the purpose of reducing surplus, making the actual charge only $1.00 per member, and reducing the assessment by about $1400.

‡ Deficit at close of 1894. Since then, each year has shown a surplus.

§ In Appendix F, for 1894–1901, as printed in the JOURNAL for January, 1902, the gross receipts, $331.50, were given, by oversight, instead of the net receipts, $244.10.

APPENDIX H.

Comparison of Conditions, 1901, 1902, 1903.

	1	2	3	4	5	6				7				8
						Gross Cost of Journal.				Net Cost of Journal.				
						a	b	c	d	a	b	c	d	
December 31st.	Members on Mail List.	Total Pages in Journal.	Printers' Bills.	Cost of Illustrations.	Cost of Manufacture.	Total.	Per Page.	Per Member.	Per Member per 1000 Pages.	Total.	Per Page.	Per Member.	Per Member per 1000 Pages.	Net Assets.
	App. G, Col. 2.	App. G, Col. 6.	App. C, Col. 5.	App. G, Col. 16.	App. C, Col. 7.	App. G, Col. 9.	App. G, Col. 10.	App. G, Col. 11.	App. G, Col. 12.	App. D.				App. G, Col. 17.
1901	1597	1074	$2734.74	$1160 90	$3599.01	$4856.64	$4.52	$3.04	$2.83	$3311.60*	$3.08	$2.07	$1.92	$2062.72
Increase	......	......	......	......	......	......	......	......	......	......	......	......	......	$538.47
Decrease	53	44	$97.61	$718 47	$689.72	$927.63	$0.71	$0.50	$0.47	$723.02	$0.57	$0.39	$0.29	......
Per Cent.	3.3	4.1	3.6	62	19	39	16	16	17	22	17	19	15	21
1902	1544	1030	$2637.13	$442.43	$2909.29	$3927.01	$3.81	$2.54	$2.36	$2588.58	$2.51	$1.68	$1.63	$2601.19
Increase	44	......	......	$331.04	$225.51	$206.23	$0.30	$0.06	$0.22	$657.00	$0.72	$0.36	$0.37	......
Decrease	......	24	$93.68	......	......	......	......	......	......	......	......	......	......	$124.65
Per Cent.	2.8	2.3	3.6	7.5	7.8	5 3	7.9	2.4	9 3	25.4	28.7	21.4	22.7	4.8
1903	1588	1006	$2543.45	$773.47	$3134.80	$4133.24	$4.11	$2.60	$2.58	$3245.58	$3.23	$2 04	$2.00	$2476.54

* See Journal, Vol. XXVIII, No. 1, page 48, January, 1902.

REPORTS OF AUDITORS.

FOR 1899.

BOSTON, MASS., February 5, 1900.

The undersigned, having been requested by the retiring Chairman of the Board, Prof. George D. Shepardson, to audit the books and accounts of the Secretary for the year 1899, would report that the books have been correctly kept and in a businesslike manner, that satisfactory vouchers have been shown for the expenditures and that the balance on hand December 31st was $1866.34.

S. E. TINKHAM,
HENRY MANLEY.

FOR 1900-1901.

31 MILK STREET, BOSTON, February 8, 1904.

I have examined the accounts of the Secretary of the Board of Managers of the Association of Engineering Societies for the calendar years 1900 and 1901 and found them correctly cast and properly vouched.

FRED BROOKS.

The undersigned has made such examination of the accounts of the Secretary of the Board of Managers of the Association of Engineering Societies for the calendar years 1900-1901 as to satisfy him of their general correctness, and has also conferred with Mr. Fred Brooks, Auditor, relative to the same, and accepts and concurs in the statement that they are correctly cast and properly vouched.

JOHN R. FREEMAN.

NOTE.—Mr. Brooks's and Mr. Freeman's reports have been delayed by the fact that numerous slight discrepancies, discovered by them in their examination of the books early in 1902, have, owing to want of time, remained unexplained or unadjusted until recently.—*Secretary.*

FOR 1902-1903.

The undersigned appointed by the Chairman of the Board of Managers of the Association of Engineering Societies to examine the books and accounts of the Secretary of the Association, for the calendar years 1902 and 1903, have attended to that duty and find them correctly kept, with satisfactory vouchers for all payments and that the cash balance in his hands December 31, 1903, was $1495.61.

HENRY MANLEY,
S. E. TINKHAM.

NOTE.—The Reports of Auditors for 1900-1901 and for 1902-1903, although dated February, 1904, are printed in the JOURNAL for January, which, in accordance with our custom, goes to press in February.—*Secretary.*

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

VOL. XXXII. FEBRUARY, 1904. No. 2.

TIMBER CRIB FOUNDATIONS.

BY GEORGE B. FRANCIS, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, January 14, 1904.*]

IN the following article the writer desires to describe his own experience in the construction of timber cribs for different purposes in various parts of the United States, and no attempt will be made to set forth all the uses for which they may be constructed, or to explain the many combinations in which the constituent parts may be arranged.

Generally speaking, a timber crib may be said to be one of the big, crude structures which engineers use for temporary work when built above water, or to save money on initial cost. When placed in water not infested with destructive worms, they are, if carefully made, structures for permanent work.

CRIB AT HALLETT'S HADES ON THE OREGON RAILWAY AND NAVIGATION COMPANY'S LINE, COLUMBIA RIVER, OREGON. BUILT IN 1883.

Fig. 1 shows Hallett's Hades, a point about twelve miles west of The Dalles, Oregon, where the railroad track passes closely along the base of a precipitous cliff, varying in height from 100 to 500 feet. This cliff was in fact blown off for the formation of the roadbed. Its rock is of volcanic formation, and of such a nature as to be displaced by the frosts and winds, in blocks from a few pounds to a few tons in weight. At times scarcely an hour would pass without pieces of large size falling and causing damage to track or passing trains. In consequence, it was necessary to keep watchmen constantly on duty, and oblige all trains to slow down

*Manuscript received January 25, 1904.—Secretary, Ass'n of Eng. Socs.

and run with caution. Instances have occurred where masses of falling rock have broken through the roof of a passenger car.

On the river side of the track the rock slope made off into the river at an angle of one to one, and at low-water stage the river was about 30 feet below the rail level.

The company decided to build a sawed-timber crib, several hundred feet in length, on this slope, so that the track might be moved from the face of the cliff about 25 feet, and placed on the crib beyond the range of falling rocks. On account of less expense it was considered preferable to build a crib than to make a fill, as the water was of great depth.

A firm base was made by casting over the lower part of the slope, and on this the timber was laid in cob-house fashion, and filled with rock. Holes were drilled in all the large boulders left beneath the crib, and the lower courses of timber were anchored to these in various ways with steel rods. At all intersections of the timber drift bolts were used. In all, several million feet board measure were put into this crib. Subsequently, some very heavy rock fell, wrecking portions of it and involving repair.

During the construction of this crib it was my duty to mark the transit lines for the location of the new track and to see that the crib was laid out correctly to fit the new conditions of alignment and grade. At one time the rodman was giving a backsight on the existing track under the highest part of the cliff when we suddenly heard the rattle of loose rock above. Looking up I saw a considerable quantity falling, directly over his head, and at once shouted to him to run; he did so (probably without waiting to hear me), and escaped about fifteen tons of material, which fell on and destroyed the backsight. These frequent falls made life hazardous for the workmen, but the work was completed without accident.

It was also a part of our duty to determine the length and amount of timber used, and each stick had to be carefully measured. On comparison with the statements of the mills, some large discrepancies were found. Investigation showed that the mills recorded the length of sticks furnished, in even figures at the nearest 2 feet, and, as the sticks averaged probably not more than 24 feet in length, a difference of 5 per cent. was not excessive. Refinement in measurement was not in vogue where timber was so plentiful and cheap. It would be interesting to know the present condition of the work, if it has not been replaced.

The photograph was taken previous to the construction of the crib. This work was built under the direction of Mr. A. A. Schenck, a Member of the American Society of Civil Engineers.

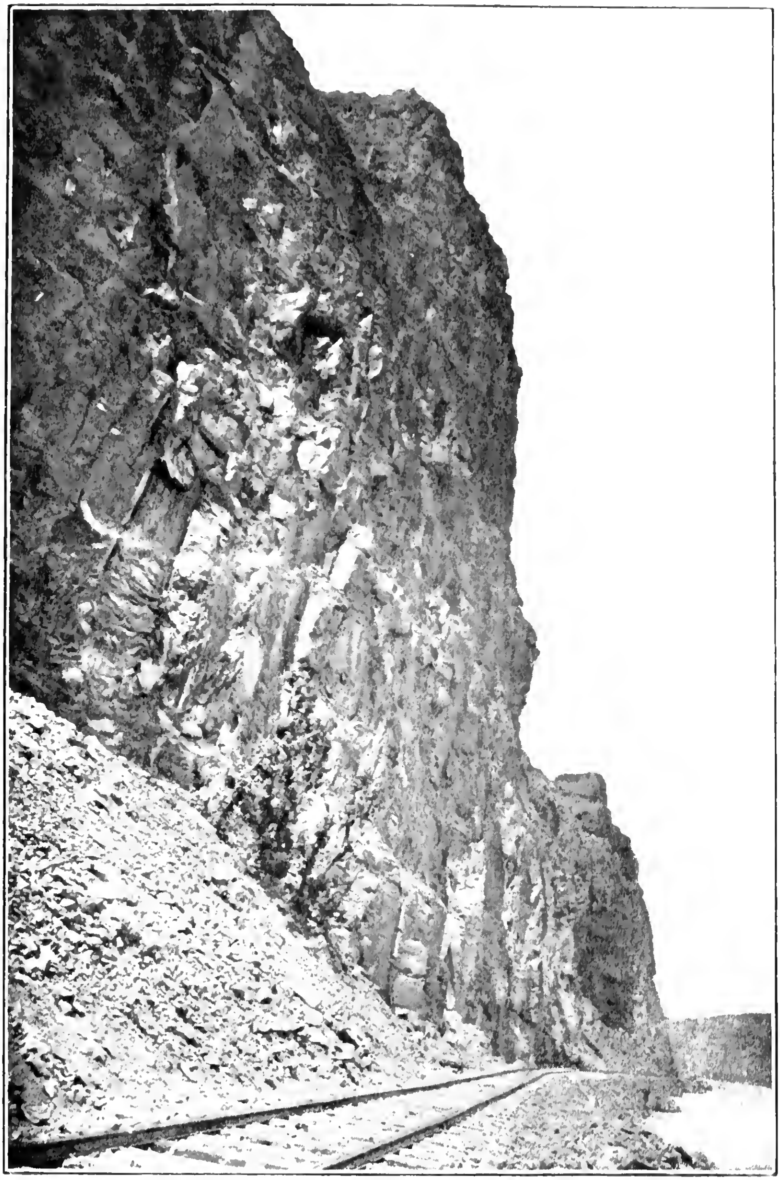


FIG. 1. LOCATION OF CRIB AT HALLETT'S HADES.

CRIB AT TONAWANDA ISLAND IN THE NIAGARA RIVER ON A BRANCH OF THE N. Y. C. & H. R. R. R. AT TONAWANDA, N. Y. BUILT IN 1886.

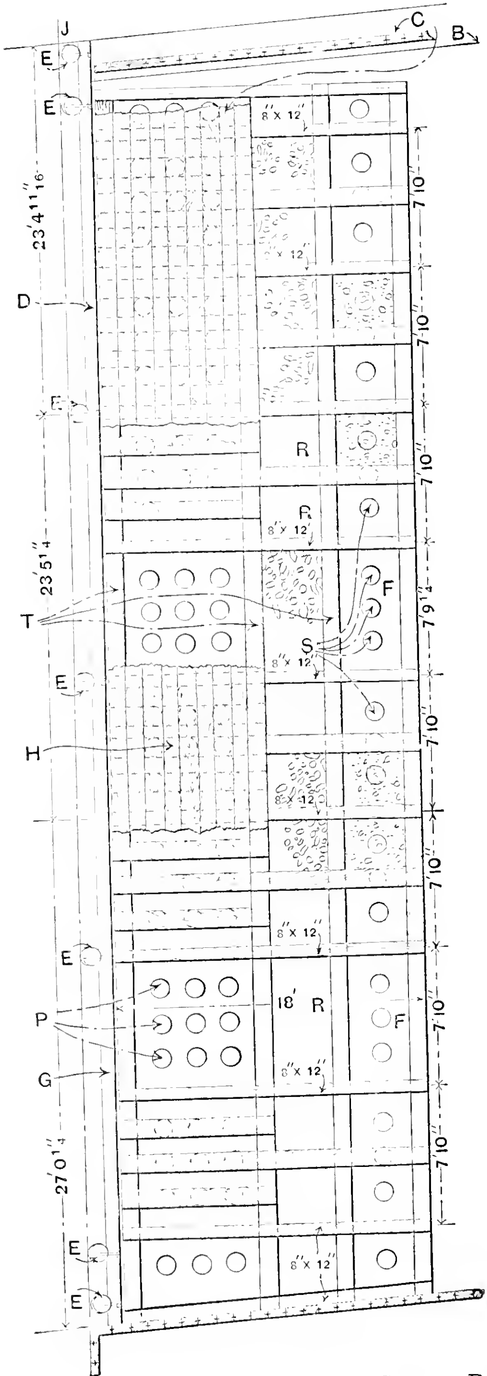
Fig. 2 illustrates the construction of one of the end piers for the drawbridge. Two of these end piers and one center pier were constructed in the manner exhibited for a single track drawbridge, in about 18 feet of fresh water, flowing at the rate of five miles an hour. As there are no worms to destroy the timber in the fresh water of the Great Lakes, this was the most economical way to construct permanent foundations for the bridge.

The cribs were built on ways, on the shore, and launched. They were then ballasted in the loading pockets, towed into position and sunk by means of additional ballast in the loading pockets. Later, piles for supporting the pier-load were driven into the open pockets, and the riprap, concrete and masonry work followed. In this construction all the timber was sized and framed together. The corner timbers being half-lapped and the cross partition timbers half-lapped and framed on a miter. It was quite a difficult matter to tow the cribs into position, on account of the strong current, and at the first trial, owing to an insufficient number of tugs, the larger crib became unmanageable. It was, however, towed to the shore, some few hundred feet below the site of the bridge, and afterward brought into position. It will be noticed on the cut that above the sixth course of timber the only method of fastening the courses one to another is by means of drift bolts put in at an angle. This work was completed in a thorough manner, at a moderate cost, as compared with masonry piers carried to the bed of the stream, and the bridge is still doing good service.

A DESIGN FOR A CRIB BASE FOR A SEA WALL FOR THE FORE RIVER SHIP AND ENGINE WORKS, AT QUINCY, MASS., IN 1901.

This design (Fig. 3) was made and submitted with a contractor's bid. The work of construction was not awarded to any bidder, but I understand that a crib based on a similar design has been adopted by the owners for this location. The scheme was to secure a wharf front, about 900 feet long, giving 30 feet of water at low tide, and to operate a heavy Gantry crane along the same.

The underlying material is of sand, and it was proposed to dredge this out and sink the crib; then to drive piling to support the wall and crane track in a firm manner. The piles were to be driven in the open pockets, and the loading for sinking the crib was to be placed in the closed pockets. It was intended that the crib be started in sections about 100 feet long on the ways on shore, then launched and completed in the water. As there are sea worms



B. Line of superstructure wall.

C. Sheet piling of cofferdam, cut off to allow plank platform to cantilever to property line.

D. 10 x 14-inch waling strips.

E. Buffer piles.

F. Filling pocket.

H. Platform under sea wall.

J. Harbor line.

P. Bearing piles.

R. Loading pocket.

S. Brace piles.

T. Stringers.

Fig. 4. Plan of Crib at Providence, R. I.

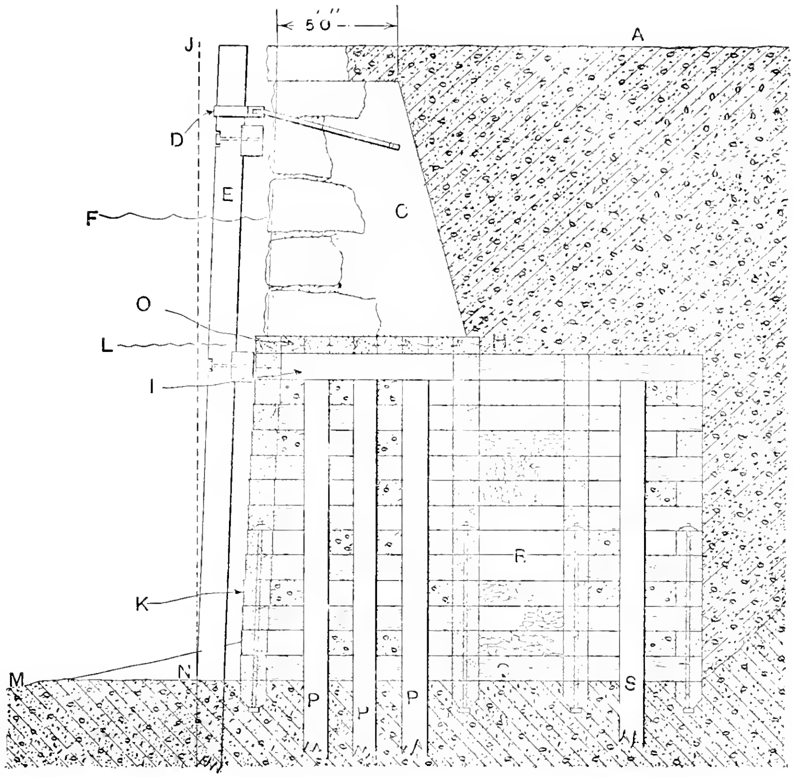


FIG. 5. CROSS SECTION THROUGH CRIB AT PROVIDENCE, R. I.

A. Approximate finished grade. El. 7.00.
B. Solid fill.
C. Portland cement concrete.
D. 4 x 5/8-inch wrought-iron collars and 2½ x 5/8-inch wrought-iron anchor bars for buffer piles.
E. Buffer piles.
F. High water.
H. Platform.
I. 12 x 12-inch pile caps.
J. Harbor line.
K. Longitudinal partitions, bolted together with long 1¼-inch tie bolts.
L. Low water. El.—5.00.
M. Present river bed.
N. Dredge line. El—18.50.
P. Foundation piles.
Q. Floor of loading pocket.
R. Loading pocket.
S. Brace piles.

in this water, it was proposed to cover the face of the crib with creasoted timber, 4 inches in thickness. Such a wharf front, including dredging and wall, could be built for very much less outlay than wall laid under water, as all of the work could be done without the aid of a diver and in a rapid manner, and at the same time would be equally permanent and substantial.

CRIB AT PROVIDENCE, R. I., FOR BASE OF SEA WALL AT THE MANCHESTER STREET POWER HOUSE OF THE RHODE ISLAND SUBURBAN RAILWAY COMPANY. BUILT IN 1902.

The conditions (Figs. 4, 5 and 6) here were similar to those at Quincy, Mass., excepting that the bottom of the channel is a

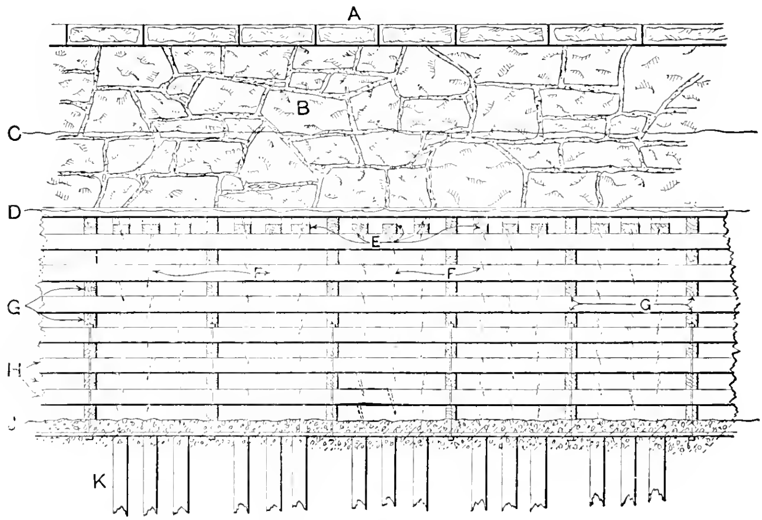


FIG. 6. ELEVATION OF CRIB AT PROVIDENCE, R. I.

A. Approximate finished grade. El. 7.00.
B. Granite-face masonry.
C. High water.
D. Low water. El.—5.00.
E. Pile caps.
F. 7/8 x 18-inch drift pins.
G. Ties, 8 x 12 inches, continuous.
H. Timbers, 12 x 12 inches.
J. Dredge line. El.—18.50.
K. Wall foundation piles.

soft river mud. The same principles were adopted, with the exception of a creasoted face planking. There are practically no worms in the upper harbor at Providence, owing to the foulness of the water. In this case the crib was built and sunk without the use of

a diver. The sea wall was built on the bearing piles driven in the open pockets.

For a sea wall against which vessels are to lie, such a crib offers a most substantial base. It is thus possible to obtain a permanent structure, built of ordinary materials, put together by inexpensive labor, above water, and, above all, at a reasonable cost.

The addition of bearing piles in the open pockets secures a firm foundation for any structure that may be needed close to the wharf front.

CRIB AT WILKESBARRE, PA., ALONG THE SUSQUEHANNA RIVER, FOR THE CENTRAL VALLEY RAILROAD COMPANY. BUILT IN 1903.

The Susquehanna River at this point has a rise and fall of about 30 feet. Owing to the other railroads having, in a large degree, pre-empted the river bank, it was necessary to locate the new double-track railroad well out toward the low-water line, save

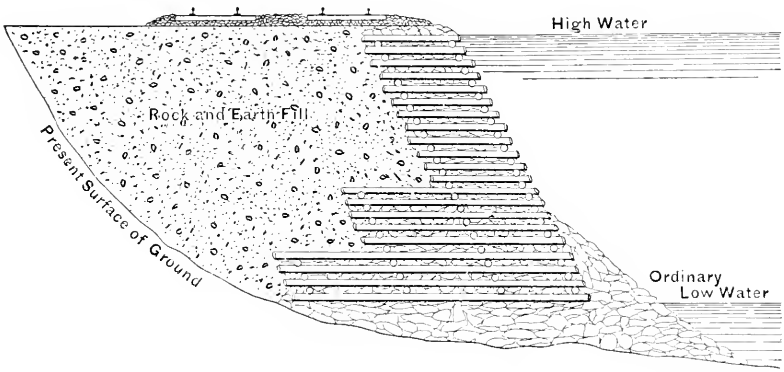


FIG. 7. TYPICAL CROSS SECTION OF CRIB, SUSQUEHANNA RIVER.

NOTE.—Transverse timbers spaced 7 feet cen to cen. Drift bolt, 7/8-inch at each intersection. Longitudinal timbers sized to make courses level. Joints of longitudinal timbers half-lapped and drift-bolted.

at certain rocky points. The construction of a plain embankment at these places involved two undesirable features: first, a slope, extending too far out into the river, and in a manner liable to meet with objections; second, the necessity of securing a large amount of material, not readily available at low cost, until the completion of the road.

A timber trestle was out of the question, as it would have to stand in the water at flood height, while heavy ice was running in the river. A masonry wall was very expensive, and its foundations somewhat uncertain.

It was finally decided to construct three round-timber cribs

(Figs. 7, 8, 9, 10 and 11), each about 600 feet long, and with maximum heights of about 30 feet. The bases are founded either on shelves cut into the river bank, or on riprap dumped into the river to above the low-water mark. The pockets are 7 feet square, and are filled with riprap. The round logs are drift, bolted at each intersection. Hemlock, spruce, pine and some hard woods have been used. It was difficult to obtain the large quantities at the proper times, and some of it had to be brought from as far away as Virginia. It was also troublesome to obtain suitable stone for the riprap. Here, again, it was necessary to go considerable distances for material, as the rock available in the immediate vicinity is an inferior anthracite mine rock, called "gob," which disintegrates upon exposure to weather.

In this work reduction of first cost was the great consideration.

CRIBS FOR CENTER AND END PIERS OF A DRAWBRIDGE AT GRAND HAVEN, MICH. BUILT IN 1903 FOR THE GRAND RAPIDS, GRAND HAVEN AND MUSKEGON RAILROAD.

In this case it was desirable to build permanent substructures at the least cost. In this fresh water there were no worms, consequently a substantial timber structure below water level would be as durable as masonry.

The work involved the removal of an old swinging highway drawbridge on simple piling, and building a new and wider drawbridge to accommodate the highway traffic and an interurban electric railroad.

This widening of structure made a new center line of bridge, and additional piles were driven, which, together with the old ones, took the new load. Around the entire piling, at each pier, cribs were built on the surface of the water, and were finally sunk, by means of stone in special loading pockets, to the required depth. They were then filled in an surrounded with riprap, to give them great stiffness. The piles, which were to support the new load, were then capped, and concrete structures carried from low water to the required height for bridge bearings. This construction gave permanent piers at low cost.

Fig. 12 shows the methods used on the center pier. The crib work was designed in New York City, under the author's direction, and executed under the direction of others at the site of the work.

IN GENERAL.

The use of rough timber cribs for cofferdam purposes is quite common. They form a substantial bulkhead, against which light sheathing can be successfully placed, even in streams where it is

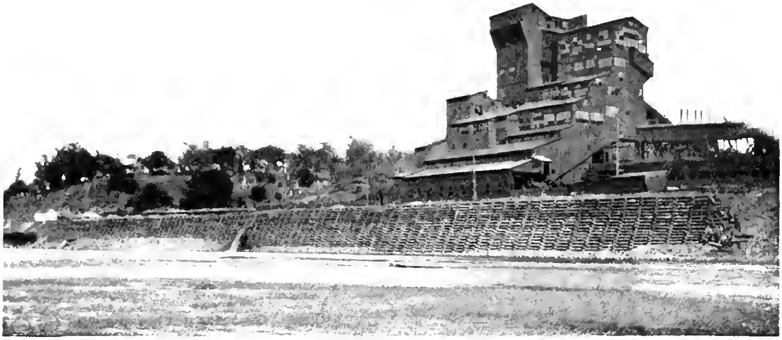


FIG. 8. CRIB, SUSQUEHANNA RIVER.

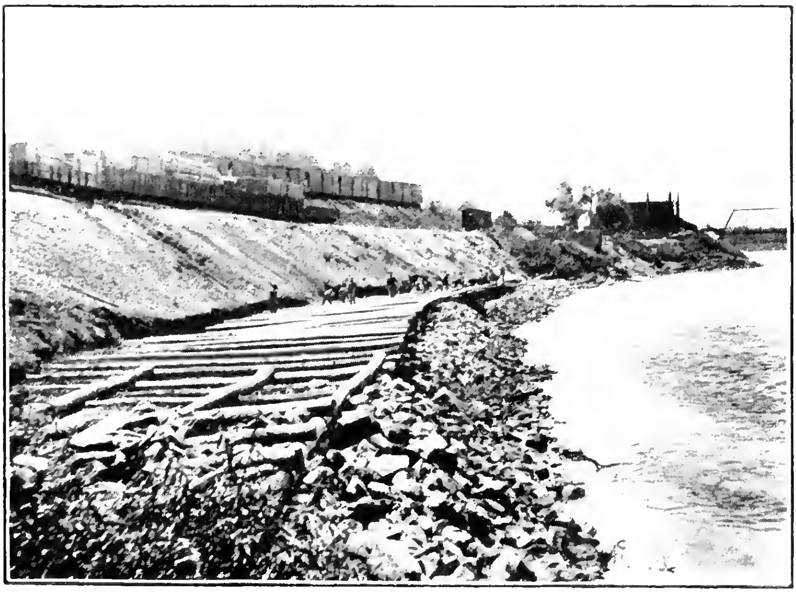


FIG. 9. CRIB, SUSQUEHANNA RIVER.

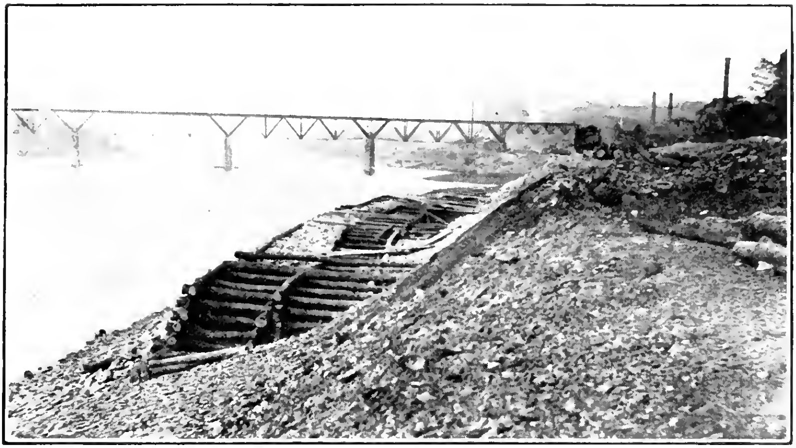


Fig. 10. Crib, Susquehanna River.

Fig. 11. Crib, Susquehanna River.

impossible to drive sheathing in the ordinary manner. But such use is, of course, temporary.

In the early days in the Eastern States (and even now in the frontier region) timber cribs were made use of for highway bridge piers. The writer saw a number of such instances this summer in Yellowstone Park, where the Government engineers had quickly and cheaply made substantial crib piers capable of lasting a dozen years or more.

A great many "cob-house" or crib docks, forty or fifty years old, were removed from the site of the South Terminal Station, in Boston, in 1897-98.

In the mud flats, on the Jersey shore of the Hudson River, opposite New York City, a great many bulkheads have been made out of round log cribs, with a base from 20 to 30 feet wide, and sunk in dredged channels. The dredged material from the front was later placed in the rear.

Crib dams are cheaply constructed, and have great lasting qualities when properly loaded with rock and earth. Even a log dwelling house is a sort of crib construction, and, compared with a frame house, is quite as durable and frequently quite as artistic.

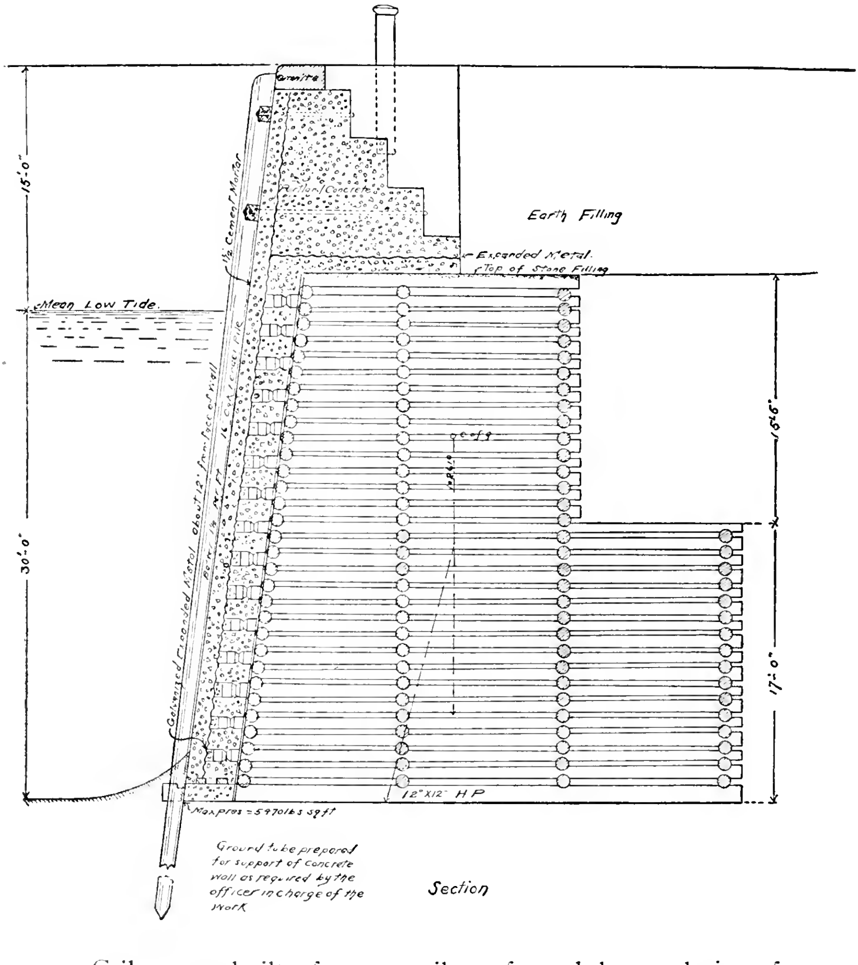
The use of crib timber in breakwaters, jetties and other marine structures, where it is covered from the attacks of worms, is very common. Timber cribs are also frequently used as curbing, sunk in dredged places around the site of large bridge piers; afterward, when buried in the riprap or gravel, they give greater breadth and stiffness to the base of the structure. Cribs of this character (Fig. 13) were sunk in the mud around the piers of the Thames River Bridge, at New London, Conn.

In this article no reference is intended to be made regarding the use of timber as "grillage," or flooring upon piling, or as platforms placed upon earth or mud to support masonry construction. There are still many uses for timber structures made in crib style, particularly where the timber is to be permanently wet. The average owner does not, at yet, realize the durability of timber construction under water where it is not exposed to worms. The engineer can often design structures of squared timber of equal permanence and shapeliness to masonry, and of greater economy, where large sums are usually expended for concrete or stone work.

DISCUSSION.

Mr. J. W. Rollins, Jr.—Within the last few years our firm has constructed several cribs, and I shall be glad to give the members of the Society the story of our experience with them.

At the Boston Navy Yard, a sea wall 700 feet long and 45 feet high from grade — 30 to + 15, referred to mean low water, was built on a crib foundation.



Cribs were built of spruce piles, of a cob-house design, from 40 to 50 feet long and 32 feet high. Pockets were filled with stone ballast, up to grade + $2\frac{1}{2}$, and a heavy concrete wall built on this foundation.

As a protection against worms, the front of the crib was protected with a concrete face wall 3 feet thick, and this face wall

was strengthened with a sheet of the heaviest expanded metal. A cross section of wall is shown in the accompanying figure.

This work was done for the Fitchburg Railroad, which, in turn, did the work under the inspection of the Government Engineers.

The cribs were built to a height of about 20 feet, on launch ways, and the front sheeting for concrete was put on; also the form for the concrete, which form was fastened, at bottom, by a bolt which could be withdrawn and the form thus released.

The engineer at first objected to building the cribs with loading pockets, and insisted that the cribs should be sunk by *loading on top*.

This crib, when ready for sinking, but without ballast, would float either with front face horizontal, or else turn through an angle of about 120 degrees. With a mass of timber 50 x 32 x 32 feet, so turning about on a balance, it was a serious proposition to sink it by loading on top, especially as the crib would naturally float 10 feet out of water.

After many futile attempts to sink the cribs by this method of loading, we persuaded the engineer to let us load them in very heavy, strong pockets, and after this we had no particular trouble.

The front form being fixed at bottom of crib, and left free to move at top, we were able to make the concrete face to a true line, even though the cribs themselves worked off of line in loading.

The face wall, only 3 feet thick, with its expanded metal fastened to ends of cross lines of piles and projecting a foot into the concrete wall, was a rather difficult piece of construction, but was put in by means of a specially designed self-dumping bucket, 20 inches wide, 4 feet long and 5 feet high. This bucket could not be dumped until it was lowered to the bottom and until a set of side dogs was thus released by the weight of the bail of the bucket.

We very soon got foul of the expanded metal and tore it out or jammed it into balls of wire. It was the universal opinion of all concerned, including the Government Engineers and Inspectors, that this metal was a serious detriment to the work, and the engineer so notified the Department at Washington; but, as is often the case where telegrams have to be made with "red tape," it was a month before we got permission to leave it out where it had been torn out by concrete buckets; and by that time we had it all in again, not caring to stop the work pending the decision. Later on, divers found that, in many cases, the expended metal had been forced into the concrete forms; and, when the forms were removed, they would take great pieces of concrete with them; also, that the

metal would be "balled up," and thus prevent the concrete from getting around the obstruction and making a solid mass.

After the wall was built and backfilled, the cribs settled out of line in two or three places, the worst case involving a backward tilt of the crib.

From our experience with these cribs, it would seem that, in order to hold them to line, the bottoms of the pockets should be filled with concrete, preferably, or else with fine-broken stone, so as to give the timbers some bearing; for, by filling the pockets alone, without regard to the timber bearings, the adjustment of the load and the settling together of the filling will almost inevitably throw the cribs out of line.

At the Fore River Works, Quincy, we built concrete walls on the crib, which was according to a plan submitted by Mr. Francis, the only change made being a change from rubble to concrete.

The cribs and all the foundation work were built by the Fore River Company, and they had various troubles in their work.

In places, the material dredged was running sand, and it took so flat a slope that the back row of piles tipped over to quite an angle, and, of course, had to be redriven. Possibly the dredging was carried too deep and too far in, and this helped the sand to run down from these piles.

Again, in filling the cribs after they were sunk, very poor material was used, and the cross-ties between the walls, made of 10 x 12 timbers, were broken by sinking an old car float on them, which allow l the finished wall to be forced out of line, cracking it badly, .d also taking the back wall with it. Rods were then put in between the walls, and these have held the walls in line.

The Fore River Company sunk these cribs by loading pockets, almost to submersion, towing them into place, then holding them at true grade and line on four heavy piles at the corners, and filling, under the bottom timbers, with blocks placed by a diver.

In places, the sand slid down and filled up the dredged bottom, which fact was not found out until the crib was sunk, and then a sand pump and jets were used to get the sand out and the crib down to grade, but with rather poor success, the cribs finally being very uneven as to grade and badly out of line.

The method of tying cribs together with timber ties seems open to the objection that, unless great care is taken in filling the pockets, these ties may be broken; and, as the filling is generally done by a dredge, large masses of material are dumped, and this material is apt to strike and break projecting ties.

FIG. 2.

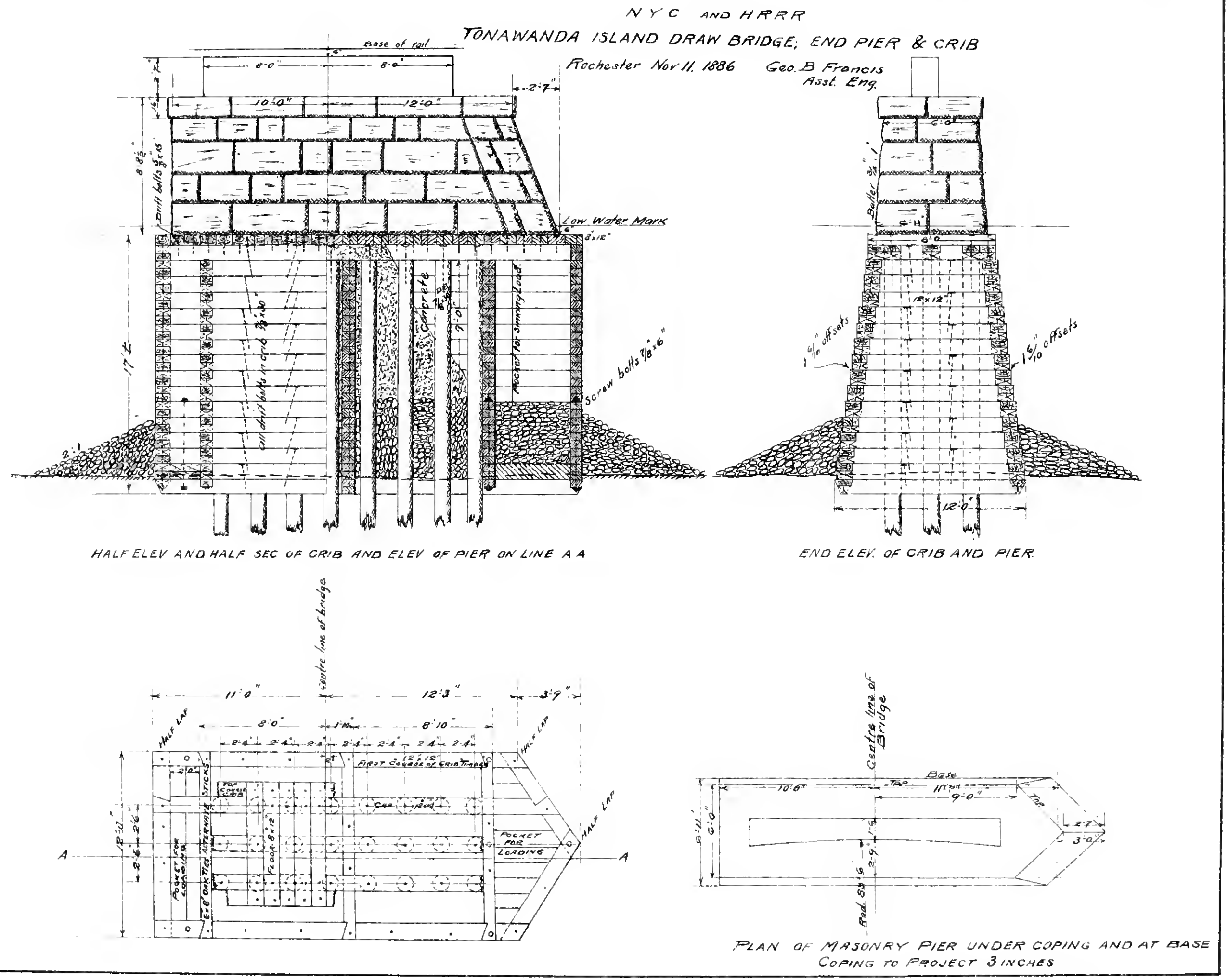

N Y C AND H R R R
TONAWANDA ISLAND DRAW BRIDGE; END PIER & CRIB
Rochester Nov 11, 1886
Geo. B Francis
Asst. Eng.
Base of rail
Low Water Mark
Drift bolts
Concrete
Pocket for sinking Load
Screw bolts 7/8 x 6"
1 6/10 offsets
Batter 3/4" 1'
HALF ELEV AND HALF SEC OF CRIB AND ELEV OF PIER ON LINE A A
END ELEV. OF CRIB AND PIER
Centre line of bridge
HALF LAP
FIRST COURSE OF CRIB TIMBER
POCKET FOR LOADING
FLOOR 8 x 12
Centre line of Bridge
Base
Top
PLAN OF MASONRY PIER UNDER COPING AND AT BASE
COPING TO PROJECT 3 INCHES

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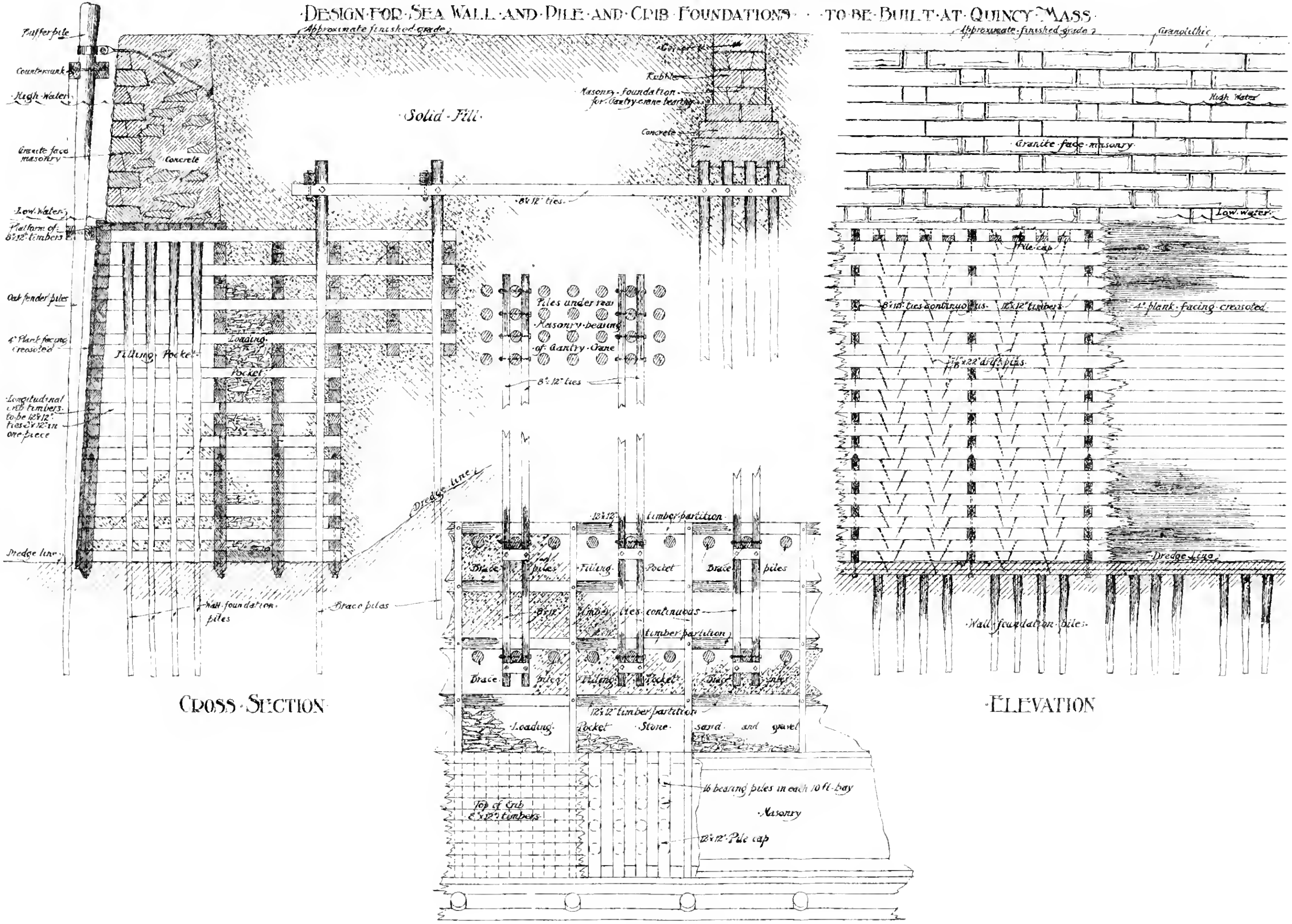
FIG. 3. ·FORE·RIVER·SHIP·AND·ENGINE·WORKS·

·DESIGN·FOR·SEA·WALL·AND·PILE·AND·CRIB·FOUNDATIONS· ·TO·BE·BUILT·AT·QUINCY·MASS·



CROSS·SECTION

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This same trouble developed at the Boston Navy Yard, in building a cofferdam for the new drydock, where the ties were broken by the filling, and the crib, for a great length, collapsed outward. Iron rods were then used, with heavier side construction, and these have given perfect results.

We have used timber cribs, as a form for concrete for deep-water construction, in various places and with no great difficulties.

At Bangor, for a pier in the middle of the Penobscot River, in 22 feet of water at low water, with a rise of tide of 16 feet, a crib was built of 3 x 12-inch hemlock plank, 80 x 22 feet in plan, with loading pockets. This crib was sunk into place, and all the pockets were filled with concrete, deposited by means of a bucket.

We had great difficulty here in getting the crib down to grade, it being placed between two bents of a temporary trestle, and these bents were too close to the sides of the crib to allow for dredging a space wide enough to receive the crib at the bottom of the river. A water jet was used to straighten the crib out and to level off the bottom.

Generally, in cases where cribs are to be used, great care should be taken; first, to excavate the bottom down to proper grade, or even a little below, before the cribs are sunk; and, second, as above stated, to hold the cribs in place and fill solid enough under the bottom timbers to get a proper bearing for the crib itself until the pockets are filled.

At Concord, in building a dam across the Merrimac River, we have turned the river through a canal and an opening in the masonry about 60 feet long, and we propose to close this opening with a crib, floated into position and sunk, and then drive sheet piling outside. In this case we have prepared a concrete wall to solid rock, against which the sheet piling will be driven.

For very many purposes, and in many places, cribs make the most feasible construction, and, if carefully and properly designed, they can be used for permanent work, at a far less cost than any other form of construction.

THE PLACE OF THE GREAT RAISED BEACHES IN GEOLOGY.

By Herbert W. Pearson, of Duluth, Minn.

[Abstract of an address read before the Detroit Engineering Society, January 22, 1904.*]

Before entering upon the subject of the raised beaches, the speaker discussed briefly some of the contested points in early geologic history. It was shown that, from about 1775 onward for thirty to forty years, the general belief was that all inclined strata found in elevated positions on the flanks of mountain ranges had been deposited in the exact place where found by an ancient ocean which had once covered the highest land whereon these sedimentary deposits were located.

With the advance in knowledge, however, it was seen that an elevated ocean, in continuous position at this high level, would not explain observed phenomena in the strata.

It was discovered that these waters must have often retreated some hundreds or thousands of feet from their original elevations, and, after such retreat, must have again advanced over the lands approximately to their old altitude. It was also learned that this alternate advance and recession had been many times repeated, and this oscillation in the waters could not at that time be satisfactorily explained.

Coincident with the appearance of these unexplainable difficulties in the doctrine of Werner, a rival hypothesis was proposed. Hutton, in 1795, advanced the theory that these elevated and inclined strata had originally been deposited in horizontal position and had been subsequently lifted into their present altitudes by the contraction of a cooling crust.

This doctrine of mountain upheaval, through contraction, has always been rejected by the geometers. Dutton has expressed the general sentiments of mathematicians in this regard in the following forcible language:

"The hypothesis (upheaval by contraction, etc.) is quantitatively insufficient and qualitatively inapplicable. It is an explanation which explains nothing which we want to explain."

Notwithstanding, however, that this system has been pronounced "in direct opposition to the principles of natural philosophy" (Lord Kelvin), it seemed, to the early geologists, that it better

*Manuscript received February 11, 1904.—Secretary, Ass'n of Eng. Socs.

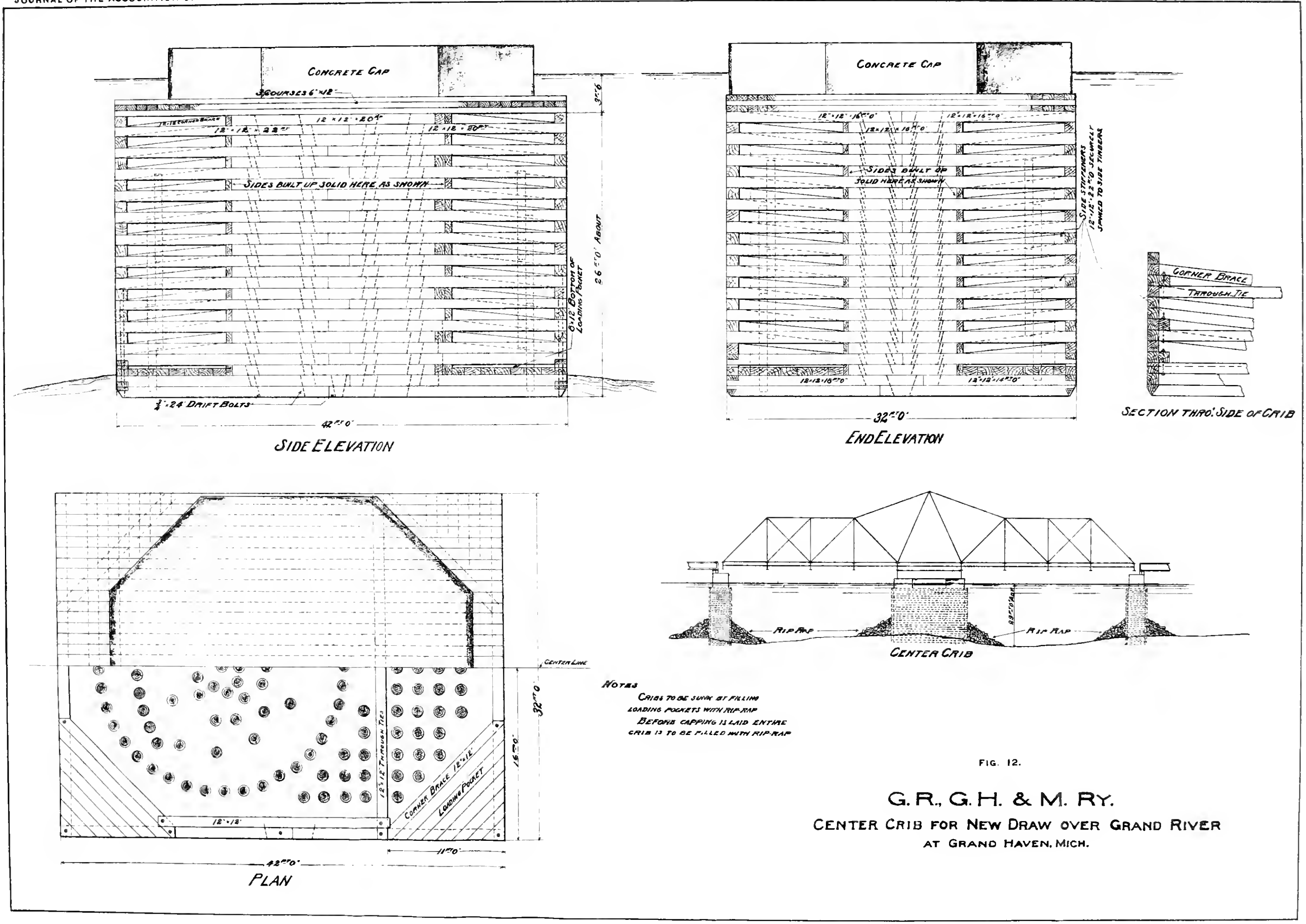


FIG. 12.

G. R., G. H. & M. RY.
CENTER CRIB FOR NEW DRAW OVER GRAND RIVER
AT GRAND HAVEN, MICH.

*Manuscript received February 11, 1904.—Secretary, Ass'n of

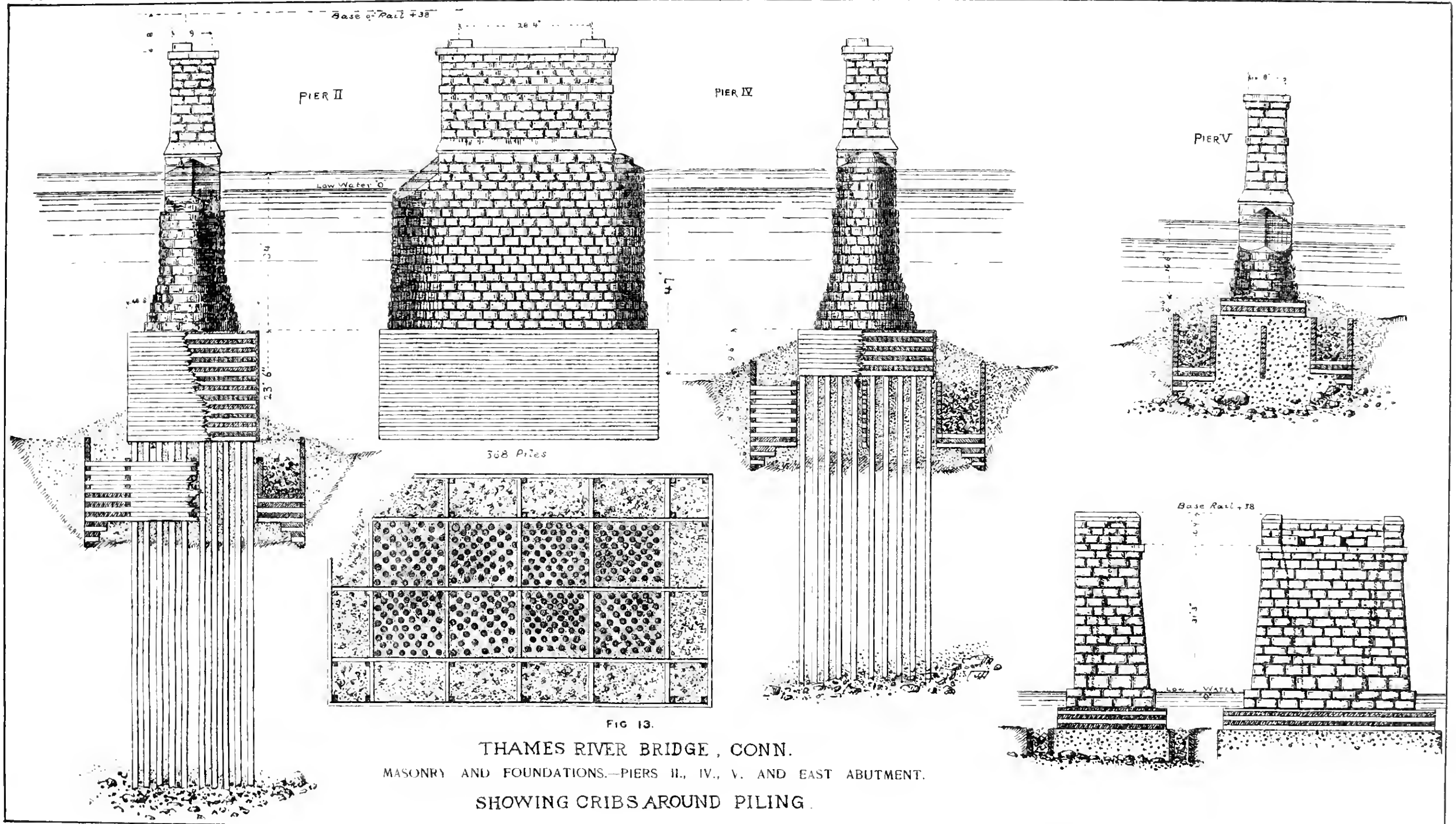


FIG 13.

THAMES RIVER BRIDGE, CONN.

MASONRY AND FOUNDATIONS.—PIERS II., IV., V. AND EAST ABUTMENT.

SHOWING CRIBS AROUND PILING.

*Mai

surmounted the difficulty in explaining these retreats and returns of an ocean than the older theory.

The idea also seemed to explain, with great logic, those slight repeated submergences and emergences of coast lines, which were known to have been in continual progress since the time of Strabo.

The geologists were therefore "compelled," they were "forced" by these arguments, to adopt this doctrine of upheaval as the *fundamental base of their science.*

It was then shown that the arguments which led to this adoption were at that time absolutely inconclusive and undemonstrable; that to-day they are still less conclusive, still less demonstrable; that the decision above noted was based solely on what then appeared to be the *balance of probability,* and that to-day, in the light of more accurate knowledge, this balance is cast most distinctly in the opposite direction.

It was then suggested that those interested in these questions should examine the history of this dispute as contained in Sir Charles Lyell's "Manual" and Sir A. Geikie's "Founders of Geology."

The speaker now began treatment of his subject proper—the great raised beaches.

Illustrations and maps of the so-called glacial lakes, Warren, Iroquois, Agassiz, Ohio, Maumee, Saginaw, St. Lawrence and Algonquin, and of the sixteen Finger lakes of New York, etc., were exhibited. All of these water bodies have been delineated by various geologists as having occupied the lowlands in the Northern United States and Canada during the last glacial epoch.

The so-called Champlain Submergence of Dana was described. This inundation is supposed to have extended over the entire eastern coast of America from Greenland to the Southern United States, and, like the glacial lakes, was in existence during the last ice age.

W. F. McGee's map of the "Lafayette Flooding" of the Southern United States was also presented. This map shows that the ocean, at some very recent period of time, covered all the lowlands of the South and extended far northward up the Mississippi Valley.

This flood covered the greater portions of Florida, Alabama, Louisiana, Georgia, Tennessee and Texas. It extended to Southern Illinois at the north, and on the Atlantic coast it reached as far as New Jersey. In addition to this great area, other writers have since shown that this same submergence extended southward to Cuba, Yucatan and the Antilles.

The epoch of this Lafayette Sea, owing to its general remoteness from the glacial border, has heretofore been more uncertain

as to date than in the case of the above-named glacial lakes, but it is now demonstrable, by means of the raised beaches, that Glacial Lake Ohio and the Champlain Subsidence of the North were both *confluent with the Lafayette Flood.* All three bodies of water can thus be shown of identical age, and we thus learn that all lowlands of the North, both inland and on the sea coast, for some reason unknown and yet to appear, were submerged *at one and the same time,* and that this submergence corresponded, in time, with a vast accumulation of ice in this same region.

It was then shown that the date of the glacial period has been fixed by the estimates of Gilbert, Wright, Spencer, Andrews, Winchell, Emerson and others as within 5000 to 12,000 years of the present.

A general description was then given of the terraces, or beaches, which have been largely utilized in mapping out the above-named glacial lakes, or seas, and narration made as to the causes which had induced the speaker to undertake the systematic study of these abandoned strands.

In this study, the Boulevard Beach, at Duluth, was first considered. This terrace is supposed to have been the coast line of Lake Warren, and is from 1075 to 1077 feet above the sea.

It was soon found that this shore line was *not horizontal.* In the sixty or seventy miles of its course first examined by the author, it had a pronounced *rising inclination to the northeast.*

This northward tilting was determined by plotting to scale all altitudes, each in its proper latitude, on a prepared diagram.

It was next learned that Warren Upham, in the Eleventh Report, Minn. Geolog. Survey, had traced out a portion of the southern shore line of Lake Agassiz, in Northwestern Minnesota, and that in these terraces he had also found a rising inclination to the north, amounting, in the case of the higher beach, to about four-tenths of a foot per mile (p. 151).

The data contained in this report, and elevations secured by a personal visit to the region, were then plotted upon the same diagram which contained the Duluth beaches, previously described, each ordinate in its proper latitude as before, and we then disclosed the interesting fact that, in equal latitudes, *Lakes Warren and Agassiz had held precisely the same elevation above the sea,* and, furthermore, their beaches had precisely the *same rising inclination to the north.*

This result, which was arrived at during the early years of the investigation, furnished the key and supplied the motive for the next eight or ten years' continuous study.

Giving consideration, then, to the facts above mentioned, we see that the surface of these ancient seas, in an eastern and western direction, fell into *one horizontal line,* and this level line was then extended, by additional data, considerably to the east.

Diligent search was then undertaken, with a view of prolonging the north and south inclination as far in each direction as possible.

In a short time it was found that the upper surface of Lake Ohio, which was supposed to have been restrained by a 932-foot ice dam near Cincinnati (Claypole), fell into line as a mere prolongation or continuation of this same inclination determined as above for Lakes Warren and Agassiz, and this curve was prolonged still farther to the south, as follows:

The area of the Lafayette Sea in the Southern States had been mapped principally from a study of the silts, soils and clays of the submerged region, while the so-called glacial lakes have been delineated from limits fixed by the ancient beaches. This latter method is clearly the proper one to use in such mapping, as the silts and clays are generally deposited at some distance from a coast line, and in no case can they be depended upon to indicate the maximum elevation in the water's level. A visit was made, therefore, to the region south and west of Cincinnati, which resulted in extending the terraces and alluvial plains of Lake Ohio well into the Lafayette area, proving thus the confluent nature and equivalent age of these waters.

Eventually, by similar methods, this curve or line of inclination was extended to the northern coast of South America.

The same process above described was next used in bringing the beaches of England, Scotland, Ireland, Norway, France and the Mediterranean coasts into order, the ordinates extending from Spitzbergen on the north to Tunis and the Red Sea on the south, and the result obtained from the two continents thus treated, after ten or twelve years' continuous labor, was the production of the curves shown in Fig. 1.

The speaker then urged the profound importance of this diagram as regards the effect it may have on geological speculation, *provided it represents the facts as stated.*

For instance, these curves deny all ice dams. They affirm that all these so-called glacial, fresh-water lakes were, in fact, but arms of a salt sea. They say that all these contemporaneous submergences of the North were but fragmentary portions of one *confluent universal ocean,* which submerged the entire hemisphere from the Amazon to the most northerly part of Greenland.

Again, it is apparent that the true and nearly concentric nature

of these curves show that since these beaches were carved there has been *no movement in the earth's crust*, or deformation in these curves would have made such motion traceable.

These inferences, and many others, follow from even a casual inspection of the diagram, and all are directly contrary to the general teaching of geologists.

Our next duty should be to seek a possible explanation of the extraordinary symmetry in these curves, and in this search there is but one physical cause that can be considered adequate to the purpose.

This cause must be looked for in the assumption that the north-

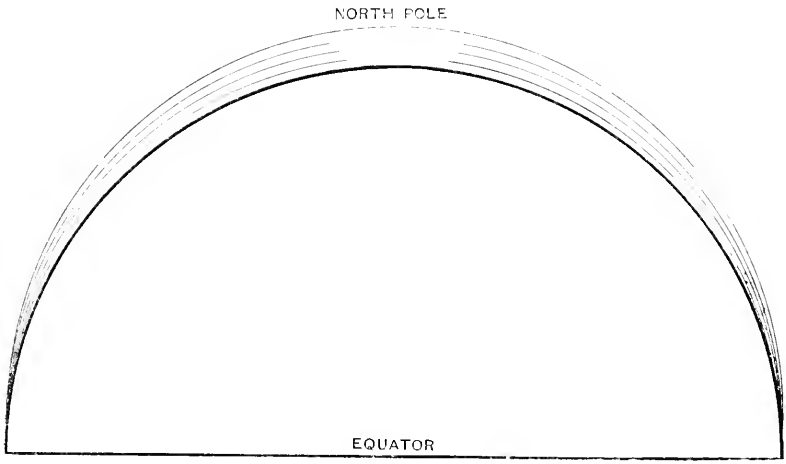


Fig. 1.

ern submergence may have been due to the shifting of the earth's center of gravity under the effect of that glacial accumulation which we know was contemporaneous with the submergence.

The mathematicians have agreed that this cause may have been sufficient to meet all requirements (authorities quoted, Rev. O. Fisher, Archdeacon Pratt, R. S. Woodward, D. D. Heath, Lord Kelvin, etc.).

It was then pointed out that if this system was to be utilized in explaining our curve, a present accumulation of ice at the south should be found, the mass of which, *added to the change due to the disappearance of our recent northern glaciers*, would be competent to our necessities.

It was then shown, under the assumption that glaciers of continental magnitude are *similar solids*, and that their masses would vary as the cube of, say the mean continental diameters, and from a study of the known facts as to the Greenland ice elevations, that

Greenland contains to-day over 1,000,000 cubic miles of ice; that the Antarctic Continent, which has a diameter about three and three-quarter times that of Greenland, must therefore contain at least 50,000,000 cubic miles of ice in excess of that in the North, and this amount was found fully capable of producing the required change in the earth's center of gravity.

In other words, the decay of one cap, the building up of another, combined with the effect from the rearranged water, affords ample physical reason for the great raised beaches, for the extraordinary continuity and symmetry in their courses and for the elevation of 1467 feet which the more recent terraces would reach when prolonged to the pole.

While engaged in the above-described investigation of the shore lines of the glacial lakes, a great mass of data had been accumulated as to *older* and *higher* terraces than those shown in Fig. 1.

These ordinates, when plotted, showed the same peculiarity in structure as those previously mentioned, except that instead of running into the ocean level at the equator, they held, at that point, considerable altitude above the sea.

They also appeared to show a general and *progressive increase in depth* in these northern submergences as we went backward in time.

In seeking explanation of these unexpected results, we find as follows: Through the precessional oscillation of the earth's axis in a period of 21,000 years, and the eccentricity of the earth's orbit, winter occurs at present in the North while we are *nearest* the sun. At the South it occurs when *farthest* from the sun.

Eleven thousand years ago these conditions were reversed, and 10,000 years in the future present conditions will be again reversed, we having our winter at these periods when farthest from the sun.

Now, Dr. Croll, in "Climate and Time," has advanced much physical, meteorological and astronomical data, leading to the conclusion that such hemisphere as has its winter in aphelion must necessarily have a *lower mean temperature* than its opposite, and he argues that these lower temperatures, due to cosmical causes, may have been the occasion of glacial epochs, and, if so, such epochs would be cyclic in nature and often recurring.

This argument of Croll's has been accepted by many scientists; by others, however, it has been deemed inconclusive.

Sir A. Geikie admits the idea to contain "The first fruitful suggestion in this matter."

Alexander Winchell accepts Croll's conclusions, and Dr. Ball, with many others, admits an "astronomical cause" for ice ages, etc.

This hypothesis of Dr. Croll seemed so logical, it seemed to have so much scientific support; and as the facts as to the disappearance of a northern glacier 10,000 years ago, its presence in the South to-day and the established fact that the Southern Hemisphere is to-day the colder were all in exact accord with the requirements of the theory, it was assumed, as most probable, that explanation of these older terraces might be found in a *succession of glacial epochs* in the North, with intervals of 21,000 years.

Fig. 2.

It was now recognized that if merit should be found in this scheme, great geological results should follow these repeated inundations; explanation would be found for the Tertiary, Triassic, Silurian and other seas, which the geologists insist have repeatedly submerged the North, and, furthermore, and what was of still greater importance, it would allow us to introduce *chronology into geology*, by separting these oceanic invasions by the cyclic period of 21,000 years.

In following up this astronomical idea as to the cause of Noah's and other floods, we now map out the United States as it appeared

when some older and more elevated submergence than that of the last glacial age covered the North. We will choose a polar depth of 2000 feet instead of that of 1467 shown in Fig. 1.

Fig. 2 represents the Eastern United States during such northern inundation. The beaches of this period indicate a depth to the waters of 845 feet in Southern Florida, 1150 feet at Cape Hatteras, 1312 feet at New York City and 1380 feet in Southern Nova Scotia.

The ice cap, the cause of this submergence, is shown in dark shading in the Northern regions, and has been located from limits fixed by American geologists for the last glacial invasion (7th An. Rep. U. S. G. Survey, Plate 8).

Examination of Fig. 2 discloses the following facts: Nearly all the Eastern and Southern States are found buried under an accumulation of ice, or covered by the waters of a glacial sea. The Appalachian Mountains rise above the waters; likewise an elevated area in Missouri and Arkansas designated as Ozark Island.

We learn, also, that the submerged areas, northward from the equator to Long Island, aggregate at least three million square miles or more, and we know that much of this lowland to-day bears the most prolific vegetable growth in the world.

This brings forward the question, What has become of the forest débris which must have been prostrated by this advancing sea?

The geologists are unanimous in agreeing that the wide ocean has repeatedly passed over the lowlands of the North; they are positive that vast areas have been so submerged as recently as within a few thousand years, but, in so far as we can learn, not one of these geologists has attempted, or even suggested, that geologic provision be made for the vegetation which such seas would necessarily overthrow in their advance.

Notwithstanding this neglect, however, guided as we now are, by a hypothesis which calls for the devastation of the present forest areas by oceanic waters in the near future, we cannot avoid consideration of the problem as to what will become of this great mass of vegetation.

It is plain that the débris of forests drifting in the sea will primarily be subject to the influence of oceanic currents; if we would follow, therefore, this material to its final resting place, we must attempt determination of some law, if such exists, by which we can predicate invariably the geographical position and the direction of flow of these streams at any one of the many different elevations of the sea level we have been discussing.

In pursuit of this law we reason as follows: Under our hypoth-

esis, a vast accumulation of water now submerges the South. These waters will soon be compelled to begin their journey to the North. Let us assume that this transfer has commenced, and let us attempt to discover the route or path these waters must adopt.

The earth's surface at the equator has a motion to the east, due to the daily rotation of, say 1040 miles per hour; in latitude 70 degrees South the velocity is but 350 miles per hour.

Let us now take a unit of this northward-moving water at latitude 70 degrees in the South Atlantic, where the eastward motion of the earth's surface is 350 miles per hour, and move it instantaneously to the equator, where the surface has a velocity of 1040 miles per hour.

We then observe that this unit immediately starts an apparent movement toward the coast of South America at the rate of nearly 700 miles per hour.

This transfer of water will certainly require a period of months, instead of being instantaneous, as supposed herein; but the fact remains that if water is passing northward from the given position in the South Atlantic, it can never reach the equator until it has undergone an acceleration in its eastward motion of 700 miles per hour.

This acceleration may be obtained by any one of three methods. The waters may, in their northward journey, press against other currents of water; they may be crowded to the east by the irregularities of the ocean bottom, but their final acceleration must certainly be acquired from their impingement on the entire eastern shore line of South America, from which there results the necessity of assuming that the waters adjacent to this coast will be heaped or piled up *far above the normal level of the sea.*

This heaping of the waters on these shores, combined with the fact that the easterly apex of the continent is considerably south of the equator, compels the diversion of the northward-moving current into the bight of the Gulf of Mexico, where these waters receive the final acceleration due to the earth's rotation.

We see, also, that in this gulf the surface of the ocean must necessarily be far above the normal sea level, and, consequently, the escape of these waters through the straits of Florida at a rate of four miles per hour needs no further explanation. This velocity of flow is due to the hydraulic head in the Gulf of Mexico, and the convexity of surface in the escaping current is a physical necessity from the attendant circumstances.

Waters flowing from the gulf and still moving northward are now always traveling faster to the east than the surface of the

earth over which they are moving. They are, consequently, compelled to a direction of northeast, and, having left the Florida shores with a velocity of about 1000 miles per hour, they must suffer retardation of something like *600 miles per hour* before reaching the coast of Scandinavia, where the final retardation must be accomplished by the crowding of these waters against the coast lines of Norway and the British Islands. Here, also, the sea level must necessarily be deformed and raised far above the normal.

It follows, from this discussion, that if water is passing northward in the Atlantic, it can by no possibility follow any other route than that of the present Gulf Stream. It follows, also, that with any change in shore lines, due to the elevated seas we have under consideration, the paths and positions of the ocean currents of the period, with their direction of flow, can still be determined through application of the same analysis.

In confirmation of this idea of deformation of sea level by ocean currents (see discussion by William Ferrel, *Science*, Vol. VII, p. 75), reference was made to Vol. XXII, *Encyc. Brit.*, p. 608, where the North Sea and Atlantic are shown to be from two to five feet higher than the Mediterranean, and to the United States Coast Survey Report for 1899, where many lines of level are unanimous in showing the same condition between the Gulf of Mexico and the Atlantic, the gulf being the higher, by various results, up to over one meter.

In the first case, this artificial elevation in the North Sea was held to be "difficult to explain on mechanical principles." In the case of the Coast Survey, the result from leveling was deemed so improbable that the level net adjustment for the United States has been fixed under the assumption that the waters of the Atlantic, the Chesapeake and the Gulf of Mexico *are at one elevation.*

All these decisions are clearly erroneous; they are in opposition to known fact; they are in opposition to hydraulic principles; and in future discussion of these questions consideration must be given by engineers to Ferrel's law in these matters.

From the results of our study of ocean currents, we now place on Fig. 2 certain arrows, which represent the position of the Gulf Stream at this epoch of northern submergence, and its approximate direction of flow, as determined by our argument.

We next examine, with a view of learning where currents flowing in the directions indicated would transport the débris from our overthrown forests, and make search for bays, estuaries, lagoons or catch basins, wherein drift material such as described might become lodged or embayed in permanent position.

At the first glance it is seen that the boundaries of this inundation, as shown in Fig. 2, *reproduce almost precisely the boundaries of the carboniferous area* in the United States.

The speaker then exhibited the maps of coal areas as contained in the American Supplement to the *Encyc. Brit.* (Henry G. Allen Co.), and, under the assumption that a strong current was pouring through the channel in Central Pennsylvania, between the north end of Appalachian Island and the ice cap, by reason of the elevated surface of the interior waters, demonstrated that the coal areas in the States of Pennsylvania, Ohio, West Virginia, Kentucky, Tennessee, Alabama, Illinois, Iowa, Nebraska, Missouri, Arkansas, Kansas, Texas and Nova Scotia were, in each particular case, found in the *precise situation where the indicated currents of this oceanic invasion would have accumulated the vegetable material due to such flooding.*

We have thus traced our forest débris to its final resting place.

The great coal deposit in Southern Wales, owing to the enlarged scale of the ordnance maps of England, was shown as being subject to the same law of drift accumulation with still greater accuracy.

The Gulf Stream approached submerged England from a direction south of west. It is clear, therefore, that explanation for this deposit must be sought in some barrier exceeding 1300 feet in altitude, extending along the northern and *particularly* on the eastern side of the field, where the coal should certainly cease where the barrier ceases.

One-inch Ordnance Sheets, Nos. 231, 232 and 250, show a mountain chain in Southern Wales extending in an east and west direction and reaching an altitude of over 2000 feet.

At the eastern end of this chain a range, or, rather, a series of hills, having elevations of 1834, 1814, 1557 and 1374 feet, projects directly south. This range, which would appear as many small islands at a time of high-sea level, terminates about one mile north of the town of Risca.

From the 1374-foot barrier near this village the descent is abrupt to a level of about 700 feet.

This chain of islands is the most easterly obstruction to high-level currents in Southern Wales, and the combination of mountain range on the north with these islands at the east makes a most perfect arrangement, or catch basin, for the interception of floating vegetation. It is clear, also, that such interception must have ceased one mile north of Risca, where the elevated range reaches an end.

It was then shown by Woodward and Goodchild's geological

map of England and Wales that the coal of Wales is located within the basin above described, and that its extension southward terminates precisely where our barrier terminates—one mile north of Risca.

In a similar manner the outcrops of the coal areas of Belgium and Germany were shown to be located invariably on the elevated coast lines of a northern submergence.

Having thus shown the principal coal deposits of the world to have been located *one hundred times in succession* along the sea beaches of a submerged north, the speaker asked, or, rather, demanded the privilege of using the bounding limits of these areas, in themselves, as *original beaches*.

If this is allowed, these coal areas will then supply *one hundred* such diagrams as Fig. 1, and will confirm, to an enormous extent, the accuracy with which these curves had been derived from the raised beaches.

Reference was made to the fact that the drift origin of coal to this time has been generally rejected. This rejection has been based on the following reasons:

First. No drift theory could supply sufficiency of material.

Second. Perfect ferns "always on the top of the seam" were considered as "incompatible" with driftage.

Third. Stumps and roots in the soils beneath coal beds have been considered as "demonstrative evidence" that the vegetation grew where the coal is found.

It was then shown that these conclusions are founded on most imperfect consideration of the questions involved. For instance:

First. The submergence of continents, so universally recognized, will undoubtedly supply sufficiency of vegetation.

Second. The floating rafts of the South, some of which have exceeded 100 miles in length, are invariably covered with a dense growth of ferns. When these rafts sink, it is certain that these ferns will descend to the bottom, *each in perfect condition*, and that they will always be found on "the top of the seam."

Third. Floating vegetation borne on a rising sea will be continually advancing over a region of overthrown and devastated forests. When this material sinks, it is almost certain, therefore, to find lodgment on a "fossil soil filled with stumps and roots in position exactly as they grew."

Attention was now called to the effect the new facts brought out in this discussion must have on geological speculation of the future. For example:

Equally with the great raised beaches, the coal beds of the

world *reject the doctrine of the upheaval of mountains;* these items supply that geological evidence which has heretofore been lacking in confirmation of mathematical conclusion in this regard.

Again, the 100 coal beds, if we make allowance for the barren measures when the waters were too deep for the barriers, could all have been laid down in 3,000,000 years, or say during 140 submergences.

If we now assume the carboniferous rocks to represent one-third of the geological column, this would allow all rock strata that have been derived from water to have been deposited in 9,000,000 years. Here geologic data again support the results from mathematical analysis; Tait and Newcomb having each determined that water could not have existed on the globe for a longer period than 10,000,000 years.

It was then stated that the apparent slight oscillations in coast lines during the historic period, which have heretofore been considered as confirmatory of the doctrine of continual movement in the earth's crust, could now be demonstrated as being due to *movement in the sea;* that these motions were periodic in their nature; that the length of this period had been determined approximately, and that the direction of this movement, upward or downward, for any given century in the past, could now be learned through mere inspection of a sinuous curve which had been derived from these oscillations. (See article, "Oscillations in the Sea Level," in the *Geological Magazine*, London, April, May and June, 1901.)

The speaker closed by urging, with much emphasis, the necessity of entering upon that revision in geological speculation which the raised beaches seem to require and which the geometers have long demanded.

Modern geology is now, and always has been, in an attitude of direct hostility to mathematical and physical reasoning. The absolute *law* which prevails in the World of Coal; the certainty with which the universally distributed terraces deny upheaval—these facts, which are incontestable in themselves, offer a means of escape from the present situation, and, sooner or later, we shall be compelled to avail ourselves of this opportunity.

The whole weight of the argument from the coal beds, and from these traces of Werner's elevated and universal ocean, is in favor of our abandonment of the old doctrine of upheaval and of the reconstruction of geological science on the basis of a rigid and inflexible crust.

It is in this manner only that geologic fact, geologic theory and mathematical conclusion can be brought into harmonious accord.

OBITUARY.

William C. Ogden.

Member of the Boston Society of Civil Engineers.

William C. Ogden passed away at his home in Dover, N. H., October 12, 1903, after a long and severe illness of typhoid fever. He is survived by a widow, father and mother and two brothers, having lost his only child about two years previous to his death.

Mr. Ogden was born February 4, 1866, at Troy Hills, N. J.; was educated at the public schools of that place and at Rutgers College.

His first engineering work was on topographical surveys in New York State and in Michigan, in which latter State he made a survey of a portion of the Military Road Lands.

In 1893 he was appointed Assistant Superintendent of Construction of the Fortifications at Portland Head, Me. In 1894 he was Assistant Engineer in the construction of a reservoir at Yonkers, N. Y., and on the construction of the Poughkeepsie Electric Railway.

During 1895 and 1896 he was associated with the late W. E. Worthen, Civil Engineer, of New York, and from that time until his death he was located at Dover, N. H., where, by perseverance, he had succeeded in building up a prosperous business.

At the time of his death he held the office of City Engineer of Dover; was the Civil Engineer for the Commission appointed by the Governor of New Hampshire to lay out and construct a boulevard along the entire coast of New Hampshire, besides doing nearly all of the engineering and surveying required in the section of the State in which he was located, and his reputation extended over to the State of Maine, where, at the time of his death, he was employed as Engineer on a water-supply system.

Mr. Ogden was a man of convictions, and dared to follow them in the walks of everyday life. It was not his way to ask if a measure was popular; it was enough for him to know that it was right, and for this reason the advocates of temperance and any worthy reform found in him one of their staunchest supporters.

His was a pure, manly, Christian character, and he could be depended upon, wherever his word or deed was needed, for the right and true.

He was a member of the Washington Street Freewill Baptist Church of Dover, N. H., and for two years was Superintendent

of its Sabbath school. He also served for several years as President of the Young Men's Christian Association of the same city.

In closing our brief tribute to our comrade and friend, we can do no better than to quote the words of one who had the privilege of knowing and respecting him, as follows: "During the last three years it has been my good fortune to have Mr. Ogden connected with me as a Civil Engineer on much of my work, and by intimate association with him I learned not only to respect and admire him as an Engineer but to love him as a man. It is rare to find one who combined his rare professional talents, his good judgment, his unbounded energy and perseverance, his fertility of resource, accuracy of workmanship and his never-failing modesty, courtesy and patience with his noble character as a man. To know him was a privilege; to have him for a friend, an inspiration, and to lose him, a deep and lasting grief, and his friends and business acquaintances and the whole community will mourn their loss in his untimely death."

S. Foster Jaques,
A. W. Dean,
Committee.

Frank Prescott Johnson.

Member of the Boston Society of Civil Engineers.

Frank Prescott Johnson was born in Burlington, Iowa, April 1, 1859. When four years of age his parents moved to Washington, D. C., and, after a residence of six years in that city, came to Waltham, Mass., where he resided for the greater part of his life. He graduated from the Waltham High School in 1878 and from the Massachusetts State Agricultural College in 1882.

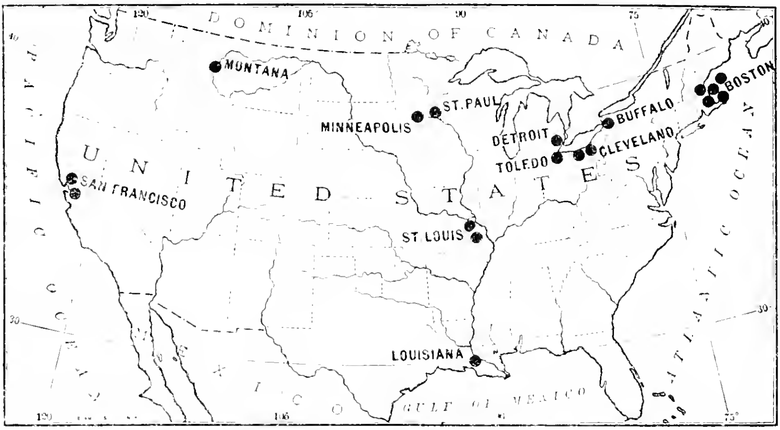
His early experience in engineering was in connection with the laying out of the Central Massachusetts Railroad, sewer construction in Boston and waterworks construction in Newport, R. I. Later, he succeeded to an engineering business in Waltham, served as Inspector for the Waltham Board of Health, and in March, 1893, was elected City Engineer. In the following year he was also made Superintendent of Sewers. In the summer of 1896 Mr. Johnson became engaged in the contracting business, and was ultimately permanently located in Bramford, Conn., where he developed a quarry for the manufacture of crushed rock and established a corporation known as the Tide Water Trap Rock Company, of which he was manager at the time of his death.

While riding a bicycle, on the evening of November 1st, the chain became misplaced and he suffered a fall which produced an internal hemorrhage and caused his death November 2, 1903.

Mr. Johnson became City Engineer and Superintendent of Sewers of Waltham at a time when the growth of the city and popular demand required an economical and businesslike administration of two growing departments. He introduced new methods and obtained creditable results.

As an Engineer, Mr. Johnson was an advanced thinker. It was characteristic of him to be looking ahead to see what improvements could be inaugurated, and, in work which he had charge of, he could be relied upon to adopt new methods wherever they could be used to advantage. He was not satisfied to follow in well-beaten paths simply for the reason that they involved fewer obstacles. He was active and enterprising and possessed that indomitable perseverance necessary to put his ideas into effect.

BERTRAM BREWER,
JOSEPH R. WORCESTER,
Committee.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

Editors reprinting articles from this journal are requested to credit not only the JOURNAL, but also the Society before which such articles were read.

ASSOCIATION

OF

ENGINEERING SOCIETIES.

Organized 1881.

VOL. XXXII. MARCH, 1904. No. 3.

THE RECONSTRUCTION OF FOUNDATIONS FOR THE HOTEL WOLLATON, BROOKLINE, MASS.

BY DANA M. PRATT, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, February 4, 1903.*]

SOME five or six years ago, the Hotel Wollaton, at 1070 Beacon Street, Brookline, Mass., was condemned as unsafe for occupancy, on account of the continued settlement of its foundations.

This settlement began during the erection of the building, and continued year after year, with the result that the walls were thrown out of plumb and the floors out of level, and large cracks appeared in all parts of the building. For some time it remained empty and fenced off from the street, to protect the public from falling walls, if such collapse should occur.

The hotel has six stories, with twelve suites, and is approximately 80 feet square. The walls are of brick above, and of heavy stone below, ground, the whole resting upon ordinary pile foundations. The location is on lowland, which might be called a "pot-hole." This lot had been filled, over a portion of the site, up to the level of the street or to about grade — 21. This was the state of affairs when the hotel became the property of Newhall Brothers, of Boston. The owners engaged French & Bryant, of Brookline, to devise some method of strengthening the foundations, so as to make the building once more habitable. The plans furnished the engineers were blue-prints of the roof and the several floors and the framing plans; also records of the soundings. Before commencing on the descriptions of repairs, it may be well to go back to the time when the first foundations were built.

* Manuscript received February 26, 1904.—Secretary, Ass'n of Eng. Socs.

The original piling plan showed about 1000 piles, or treble the number used in the new foundations.

Rumor has it that while the lower walls were going up, settlements were noticed by the masons. Walls and floors, which were left plumb and level, were found to be out of position a few days after they were laid; and, as each successive story was reached, the floors were made level. This remedy was only temporary, and of its effects I will speak later. By the time the building was done, or soon after, it was feared the foundations were too weak, and some one tried to fix them by additional outside piles and steel beams, but as far as any material benefit to the foundations went this operation might have been omitted. Owing to changes in the original building plans, after some of the foundations were built, a great many piles were driven which were not loaded; these were uncovered, holes were cut in the walls, and through the latter were placed I beams, which rested on these idle piles. The beams were pinned off at the walls and became a part of the support. These beams were mostly 15 and 20 inches deep, and, in our work later on, we found some to be from 20 to 25 feet long, supporting the wall entirely. This made a very long span for such a concentrated load, causing a deflection in the beams of nearly a foot.

At the rear wall of the building, where the settlement was the greatest, the piles were capped by a platform of three layers of 6 x 6 inches hard-pine timbers, reinforced by a layer of concrete, the walls resting directly upon this structure. All these repairs proved futile and the building still settled very slowly.

The foregoing sketch gives an idea of the conditions prevailing at the time we took hold of the work.

The first thing to be done was to examine the borings, seven in all, taken by the B. F. Smith Company.

There were seven soundings, a fair average being shown in Fig. 1.

These tests were not considered sufficient, and two 120-foot holes were made by the Brookline Waterworks to approximately grade — 100, the main purpose being to determine if suitable hard material was near enough the surface to make the use of iron piles economical. These tests showed that from grade — 30 to grade — 100 the material was sharp black sand, mixed at intervals with a little clay and gravel, until at the extreme depth it was so compact as to be almost impossible to drill.

This showed that iron piles would not be appropriate, and that the stratum of gravel at about grade — 25 to grade — 30 was the firmest for supporting the piles. (See Fig. 1.)

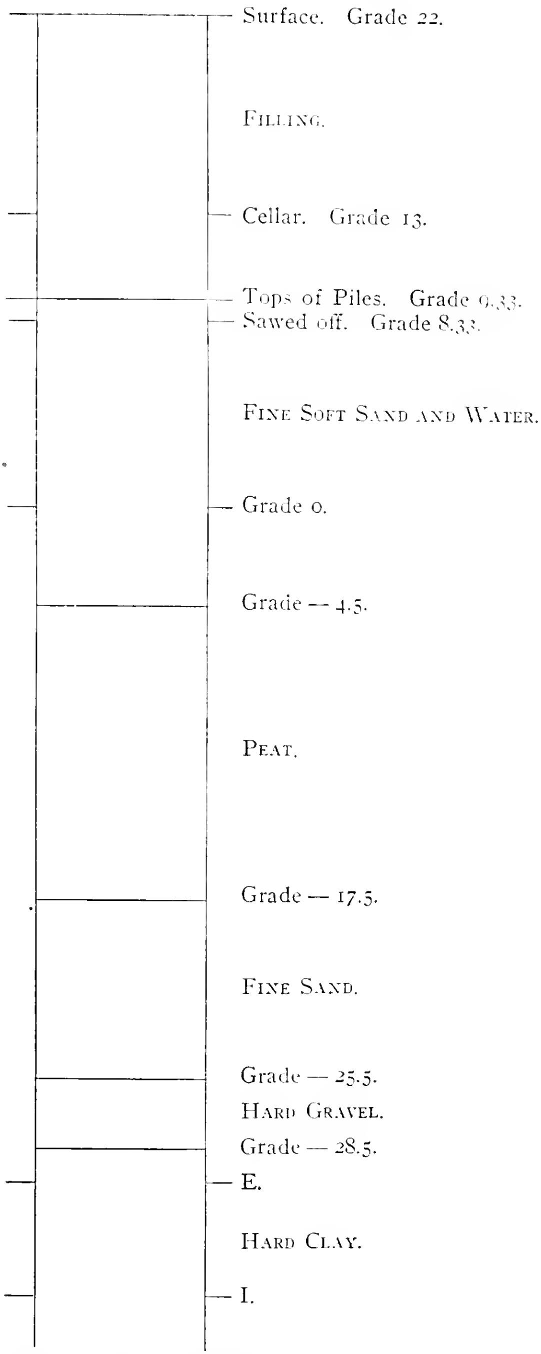


Fig. 1. Average Sounding.

E = Desired position of points of exterior piles.
F = " " " " " interior "

The following schemes were considered in the preliminary studies:

1. Loading the building and moving easterly 40 feet where the soil was firmer.

2. Open-caisson method with some wood and some iron piles, the caissons proposed being 4 feet in diameter. This method would have cost at least $16,000.

3. Moving the building westward about 90 feet on to a temporary pile support, and while it was in this position lay new foundations, after which the building was to be moved back upon them. This estimate footed up to $22,000. This method was abandoned largely on account of the walls, which were so cracked that it was feared they would not be able to stand the journey. These estimates gave from $15,000 to $22,000, and, moreover, moving the building was considered a doubtful experiment.

4. The method finally adopted was to repair the foundations and level the building, but not moving it laterally. While the foregoing studies were under way a good many measurements were made. Levels were taken over the whole lot and plotted on a one-quarter scale plan. The building was closely measured on the outside and accurately plotted. The inside arrangements were taken from the building plans and verified by observation. Levels were taken on the first, second, fourth and sixth floors in corresponding positions and the settlements compared by floors. The settlements shown by the different floors agreed generally within a fraction of an inch, a portion of any discrepancy, no doubt, being due to doing the leveling on a floor and the remainder due to the manner in which the floors were laid. The easterly front corner was in comparatively firm ground and was assumed to have retained its original level. Whether this was so or not is of no moment, for we aimed to bring all other portions of the building to this highest level. The greatest settlement on any portion of the floor was 0.92 feet, or 11 inches. Its location was on the west side, about three-fourths the distance to the rear. From these levels the settlements were contoured every 0.05 feet difference in elevation.

In order to detect any settlements which might occur during the work, especially while pile driving, small nails were driven at various points, both inside and outside the building. There were sixty-four in all; twenty-five being outside and thirty-nine inside. These were placed at salient points, such as angles in the walls, piers, elevator wells, etc. Before any work was commenced levels were taken on the telltales to the nearest 0.001 of a foot and the date noted. During the work levels were taken on these telltales at

frequent intervals, sometimes daily, especially during pile driving; the progress of the work being noted each time. These elevations were tabulated and constantly examined. In addition to these, some of the cracks in the walls were plastered with mortar. This latter method, although showing occasional settlement, was unreliable. By the table we could determine at all times the state of the walls and the chances of a collapse.

Measurements of all piers were necessary for the proper placing of piles, and also a plan of all iron beams in the first floor. These beams were placed every 4 or 5 feet through the whole floor, and the inside piles had to be located very carefully.

Location of Building.—Four offset lines were run parallel to the four sides of the building, at as short a distance away as practicable, and the ends thoroughly tied in. At various points, on the first and sixth floors, offsets were taken. The front side was found to be 0.15 to 0.20 feet out of plumb and leaning toward the rear. The back walls on the easterly portion leaned 0.19 feet toward the street, and on the westerly end leaned 0.46 feet away from it. The east wall leaned west 0.66 feet and the west wall leaned west 0.70 feet. The weight of the building, with live and dead loads, was calculated as 4000 tons, and, by means of the framing plans, we were able to determine its proper point of application to the walls. This weight was taken in sections, about forty in all, and the necessary piles computed for each section.

The general plan of the new foundations is shown in Fig. 2. Spruce piles were driven outside the building and hard-pine piles in sections inside; the tops were concreted around and capped with granite. Upon the granite caps were I beams, placed directly above the rows of piles; upon these I beams were cross I beams running from inside to outside of walls, and upon these last were a double row of beams, which carried the walls directly. All of these beams were covered with concrete. This is shown in detail in Fig. 3.

The work of rebuilding was divided into three parts, as follows:

1. The excavation, grading, sawing off piles, pumping and backfilling was let by contract to J. H. Sullivan. Bids for this work ranged from $3000 to $5200.

2. This contract included tying walls, loading and leveling building, driving piles, removing masonry and handling iron work and boiler. This contract was let to Isaac Blair & Co., of Boston.

3. The owners thought best to do all rebuilding of masonry, cutting holes for beams, setting stone caps for piles, beams, carpenter work, etc., themselves, and this was done by various laborers,

under the direction of a foreman accustomed to the construction of large buildings.

Work was commenced about October 20, 1899, both contracts being carried along together. The first work was to tie the walls of the building together on the second and fourth floors. For this purpose heavy iron rods, with turnbuckles, were used.

The first piles were driven October 23d. All piles were numbered and the penetrations recorded. It may be well to give a few

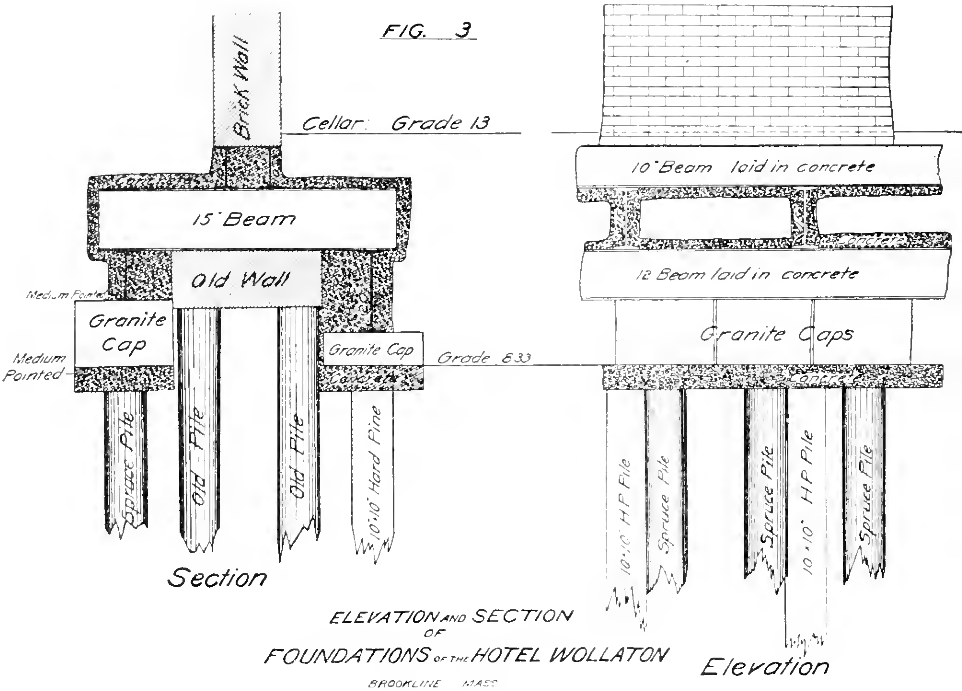


Fig. 3. Elevation and Section.
Scale, 1 inch = 4 feet.

words of explanation about them. I have previously mentioned how few there were compared with the original number. The ordinary loads given to the piles supporting buildings in Boston are 8 to 10 tons, while some of our piles were figured as having to carry nearly 50 tons. This loading was so excessive, that we searched pile-driving records to find a precedent. In *Trans. A. S. C. E.*, vol. 2, p. 155, was an article on pile tests made in Buffalo.

The conclusion drawn from these tests among others was that 1000 pounds per square foot in clay, sand and gravel was conservative for downward skin friction for a static load. The proper lengths of inside piles were worked out as follows:

The portion of the load to be borne wholly by the inside piles was 3000 to 3250 tons. By using 100 piles inside this meant 32.5 tons per pile. By using hard-pine timber, 10 inches square, the friction area of the pile is 3.3 square feet for every running foot, or 3300 pounds for the frictional resistance per lineal foot. The average load on a pile being 65,000 pounds, this gave 65,000 ÷ 3300 or 20 feet as the necessary penetration in bearing soil.

Keeping in mind that the first 25 to 30 feet was in very poor material, peat, in fact, we have 45 feet for the required length of pile; the outside piles being more numerous, were called 40 feet long.

The first pile driving was done in front of the building where the filling was the greatest. This driving was done before any excavations were made and the diggers followed shortly. As the earth was removed the piles were sometimes found to be out of plumb and out of position, owing to their striking sunken logs. After this, the excavation, down to about grade — 10, the ordinary water level, was done in advance with better results. Owing to the very ragged original foundations and other obstructions the piles could not always be driven where desired, and this is shown in the poor spacing and ragged lines shown in Fig. 2. This also necessitated the use of caps in many cases, and on this account it is quite possible that some outside pile loads reach 50 tons.

The pile driving outside was done with a Warrington steam hammer of the Nasmyth type. The hammer was made by the Vulcan Iron Works, of Chicago, and consisted of a frame supporting a steam cylinder, to the piston of which is attached a heavy cast-iron ram. This whole apparatus rested directly on the pile top; the ram traveled 19 inches and struck sixty to eighty blows per minute, and the pile was practically on the move all the time and the jar reduced to a minimum. The total weight of this iron work resting on the pile was 6500 pounds, the weight of the ram itself was only 1700 pounds. This hammer had to be kept well oiled, and at first the steam exhaust scattered the oil to the sides of the building, discoloring the light brick to a yellowish brown. It was therefore found necessary to protect the walls, and a canvas of large dimensions was hung from the walls. Taken all in all, the pile driving was perhaps the most interesting part of the whole procedure. The outside pile driving commenced October 23d and ended December 7th. There were 173 of these, and they were all spruce, furnished and driven by the contractor for $6 per pile of 40-foot length. Seventeen piles were spliced with a spruce stick and twenty-three were spliced with the hard-pine 10 x 10-inch stick, used inside the

building. For all spliced piles the contractor received double pay; this, of course, was more than they were worth as compared with single piles, but as the latter were driven at a loss, it was thought best to be liberal. Nineteen of the piles were cut and furnished by the owner from trees cut on his own estate. These were, of course, green, and were in some cases 2 feet in diameter at the top. The total weight to be supported by these piles was about 1500 tons, making on the average 9 tons per pile, with probably no pile carrying more than 12 or 15 tons. The contractor, though not engaged in the pile-driving business, found that he could drive them cheaper than he could sublet them to other contractors. They were probably

Fig. 4. Wall Before Leveling.

driven slower, but, no doubt, far better than if by a subcontractor. The force necessary was a foreman, engineer and seven or eight men. The greatest number of piles driven in any week was forty-two. This seems a small number compared with other work, but owing to the presence of the building the moving of the apparatus was slow. From notes taken of the men's time, etc., it would seem that $8 per pile was a fair price for piles driven in good shape under such conditions. The general scheme for the position of piles was 22 inches from the face of the brick walls, but the lower portion of the wall, being built of heavy blocks of granite, often gave trouble by the projections of the latter, and in many cases the piles had to

be moved and almost wedged in between the building stones and driven with a follower to get them down. In this case, 24 or 25 inches from the brick walls would have been cheaper, although taking more iron. As fast as piles were driven they were sawed off and capped. The grade for this cutting was 8.33 above low water, while a few piles, which were to have wooden caps, were cut at grade 7.5. A few idle piles were found in the line of our new ones and were capped and used, although it is doubtful if they were of much benefit.

Inside Piles.—These piles were to be driven inside an existing building and the problem was different. The specifications called for piles made of 10 x 10-inch long-leaf hard-pine timber, in 15-foot sections or lengths, spliced together with iron bands or sleeves, and it was estimated that three lengths at least would be everywhere used, and in the softest places, four. These specifications were followed, and only first-class timber was used. There were about 3000 tons to be borne by the inside walls and ninety-eight piles were used. This made 30 tons at least for the average loading per pile, and in two cases our computations showed that 46 tons would be the actual load. In a few cases, as around piers, 6 tons was the computed load. All piles were numbered, and, after sawing, were tied in. When any inside pile was to be driven the notebook showed the load to be borne, and special pains were taken with the driving in case of the heavily loaded piles. It was the original intention that the inside piles should also be driven with a steam hammer, as it was thought that better work would be done, but the contractor raised the objection that the escaping steam would spoil all the walls of the building. The real reason, without doubt, was that the steam hammer had given him occasional trouble, and, moreover, was exceedingly heavy to move about in this restricted space, besides the care of the escaping steam by a proper exhaust through the windows. We yielded the point, however, on the contractor's guarantee to drive the piles to the same depths with the drop hammer.

Work on the inside piles was begun December 10th, and was finished February 1st; the force of men employed was the same as when working outside. Before work was commenced, the finished work of the lower fireproof floor was taken up, and holes 4 or 5 feet square were cut in the brick arches vertically above the pile, likewise a hole 4 feet square was dug below the cellar floor and excavated to tide water, the pile driver was then set up and the first section driven. When the first 15 feet had been driven, the pile sleeve was placed on the head and pushed into place by the hammer.

Before driving the next stick a saw cut was made around each end, then placed in position on the sleeve below and pushed into place by the hammer. The longest piles were sixty feet and the shortest $37\frac{1}{2}$ feet. In one case an old pile was found in line of our new one and by followers was driven down to a proper grade. Four piles were all that could be driven in one day, under a contract price of $15 each, which entailed a loss to the contractor. From notes of the number of men employed, I have estimated that there was a loss of about $6.50 per pile, making $21 to $22 a fair value for such piles furnished and driven.

The pile splices cost $1.24 apiece, and were furnished by Kendall, of Cambridgeport. Throughout all the pile driving the penetration under the last blows was taken. The method used was to wait until the foreman swore he couldn't drive it any further and then have him take about ten blows. The division of the whole penetration by the number of blows was called the penetration of the last. The smallest penetration of the steam hammer was 0.01 inch, being the average of forty-five blows; the greatest being 1 inch to a blow; a fair average being fifteen blows to an inch. With the drop hammer the smallest penetration was $\frac{1}{4}$ of an inch and the largest $1\frac{1}{4}$ inches; a fair average being $\frac{5}{8}$ to $\frac{3}{4}$ of an inch. Nineteen feet was the maximum drop of the hammer. During the latter part of the inside driving two separate gins and hammers were used; one being used for driving, while the other was being erected for the next pile, and thus the only delay was a few minutes to transfer the lead rope. These inside piles were nearly all driven with a short follower.

In the back part of the building it often took a laborer two days to get a hole cut through the old timber platform below the walls. Outside spliced piles were doweled together with a 2-inch angle iron 8 inches long.

I have previously mentioned the exceptionally heavy loads to be placed on many of the piles. Although we felt safe, we could not help thinking of them, and the owners were induced to purchase for testing purposes an hydraulic jack, of 100 tons capacity, costing $125. This was of Watson-Stillman make, with 4-inch motion and 9-inch base, the pump for cold-weather use taking a mixture of 40 per cent. alcohol and 60 per cent. water. We made six tests with the jack, covering different conditions.

In figuring safe loads, the *Engineering News* formula was used, thus:

$$L = \frac{2\ w\ h}{s + 1} \text{ and } L = \frac{2\ w\ h}{s + 0.1}$$

Where "L" is the load and W the weight of hammer, both in pounds, "h" the fall in feet and "s" the penetration in inches under the last blow, a statement of the various tests which were made follows:

Test No. 1. Pile No. 100.—This was on a green spruce outside pile, 40 feet long, penetration 0.2 of an inch under the steam hammer. The formula gave 10 tons as a safe load, while the actual load was figured as 11 tons. This test began at 11.30 A.M., with a load of 25 tons, and was continued at 12 M., with a load of 30 tons.

From 1.30 P.M. to 3 P.M. the load was 35 tons; from 3 P.M. to 5 P.M. the load was 40 tons, when the test was stopped. During the test no displacement of the pile was noticed.

Test No. 2.—This was in a spliced spruce outside pile, driven with a steam hammer, penetration 0.2 of an inch, and was tested with a load of 50 tons. No settlement occurred.

Test No. 3. Pile No. 127.—This was a spliced spruce outside pile, the lower section being 40 feet and the upper 25 feet long, driven with a steam hammer, with a penetration of 0.2 inches. The jack was placed on top of the granite pile cap, and upon the application of 35 tons the pile cap settled and continued to settle until a load of 60 tons was reached. At the time this test was made there was no concrete about the granite cap, and it was at first thought that the pile might have moved; later, it was decided that this apparent settlement was simply the compression of the fibers of the pile, as in test No. 4.

Test No. 4. Pile No. 122.—This pile was a spliced spruce outside pile, the lower part being 42 feet long and the upper part a hard-pine stick, 10 inches square and 15 feet long, driven with a steam hammer. Computed safe load, 24 tons. The jack was placed on the granite pile cap as before. In this case the cap was surrounded by concrete. The results were as follows:

Load.	Settlement.
20 tons	0 inch.
26 "	0 "
40 "	$\frac{1}{32}$ "
52 "	$\frac{1}{8}$ "
60 "	$\frac{3}{16}$ "
77 "	$\frac{1}{4}$ "

The test was then stopped and load removed. When all but 20 tons had been taken off, the stone cap on the pile head came up, indicating that the pile itself had not moved, but the fibers of the pile were compressed, or that perhaps the joints had closed a trifle.

Test No. 5. Pile No. 12.—A hard-pine pile, 45 feet long, driven with a 2000-pound drop hammer, drop 18 feet and penetra-

tions $\frac{1}{2}$ inch. Safe load, 24 tons; load which piles must carry, 46 tons. In this case the test was 50 tons. No settlement occurred.

Test No. 6. Pile No. 35.—Hard-pine pile, 45 feet long, driven in three sections with 2000-pound hammer, penetration 0.7 inch. Safe loads, 21 tons; load which pile must carry, 46 tons.

Time.	Load.	Settlement.
1.30 P.M.	10 tons.	0 inch.
1.50 "	30 "	0 "
2.00 "	40 "	$\frac{1}{8}$ "
2.15 "	50 "	$\frac{1}{4}$ "
2.40 "	60 "	$\frac{7}{16}$ "

When the load of 60 tons was applied, the loading beam buckled and released the load, after which a net settlement of $\frac{1}{8}$ inch showed.

The results of these tests were very satisfactory, and indicated the piles were safe under any load we expected to put upon them.

Sawing Off Piles.—The contract price for sawing off piles was 20 cents. It cost the contractor about 50 or 60 cents. This was due to the small space in which the men worked, the narrowness of the trenches, the fact that many piles were driven hard up to the walls, and also that the men worked part of the time in the water.

During the time occupied by the driving of the outside piles, the largest settlement noticed by telltales was $\frac{6}{100}$ of a foot in the back end of the building.

On February 1st, or after all piles were driven, the largest settlement on the back was $\frac{9}{100}$ of a foot; the largest settlement on the inside was $\frac{7}{100}$ of a foot.

Granite Caps.—Every pile was capped with granite blocks with their tops and bottoms medium pointed. The depth varied from 8 to 28 inches, with $\frac{1}{4}$ inch allowance for joints. The reason for the variations in depth was that the iron beams above were of varying sizes, and it was necessary to set the tops of the middle tier of beams at the same level. Practically, all the stones were 2 feet square, and prices on furnishing and delivering these stones varied from $525 to $675. The contract was awarded to Field & Wilde, of Quincy, for the former sum. This price was later reduced to $500, provided the engineers would not be too particular about the "looks" of the stone. These stones, where possible, were bonded to existing masonry by concrete. For the proper bedding for the iron beams it was necessary that the tops of the stones should be level. This was not always the case, and a stone mason often had to point a trough through the top for a width equal to the flanges of the beams. The cost of such pointing was $30. This, in the end, was cheaper than using a more finished quality of stone. These stones were easily

handled by two men with a bar, and were lowered into place with a differential pulley. As fast as the stones were set, the piles underneath were located on the stones and marked with a cross of black paint. These stones when set were all bedded in concrete, and where they were near together the space between the edges were also filled.

ITEMIZED COST OF CAPPING PILES.

258 stone caps	$500.00
265 piles sawed, at 20 cents	53.00
Dressing stone	35.00
Chain falls	21.00
Laborers	168.40
Mason	96.39
	$873.79

Or about $3.40 per pile.

Exclusive of pumping and concreting, a mason and tender could lay fourteen stones per eight-hour day.

Concrete.—The gravel concrete used for this work was mixed 5:3:1. The first cement used was Krouse's. This was very slow setting, and we soon changed to Atlas. The concrete was wheeled out on stagings and allowed to be dropped about 10 feet into position. Gravel and sand for this work cost $1.30 per cubic yard, delivered.

Steel Work.—The total weight of steel beams for which bids were asked was 118,698 pounds, nearly 60 tons. Specifications were sent to ten representative companies, and the contract awarded to the Phœnix Iron Company, for 1.675 cents per pound, f. o. b. Huntington Avenue, Boston, from which yard they were teamed by the R. S. Brine Company for 59 cents per ton.

All iron beams were painted with two coats of red lead and were perfectly plain, without punching or drilling. There were three tiers of beams:

First. The girders forming the lowest course and resting directly along the pile caps. These acted as continuous girders and their size was not figured. These, in general, were made 12 inches deep, which seemed reasonably safe, especially as each beam was bedded in a 12-inch strip of concrete. Similar beams on the inside could be computed as a simple beam with one or more concentrated loads. These beams varied from 12 to 20 inches in depth.

Second. The crossbeams supported by the former and extending from the outside through the walls to the inside. These beams were all computed, and for the outside walls made 15 inches. Weights, 42, 50 and 60 pounds. These beams were likewise bedded

in the concrete. At the main corners of the buildings these beams were laid double or even triple, with the edges of the flanges at least ½ inch apart, to facilitate the grouting.

Third. The longitudinal beams resting on the crossbeams were laid in pairs, the extreme edges of the flanges being flush with the edges of the 16-inch wall, the space between them being filled with concrete. These were all light, 8 or 10-inch beams, and directly supported the wall above.

The first beam was set January 15th and the last not until some time in March.

The steel beams began to arrive about the middle of January, and the work of setting them commenced at once. This was the building mover's contract. The price for this was $500. This was done at a profit to the contractor, as, taken in conjunction with his other work, it probably cost him from 50 to 75 cents apiece, or not more than $150 for the whole. The work of bedding them was done by the owner. The first beam placed was on January 15th, after one-half of the inside piles had been driven. These first beams were, of course, the long one upon the pile caps. These were easily handled, the only particular work about them being the proper placing. The axis line of the beam was made to fit an average line through the centers of the piles. After these beams were in place, the position of the crossbeams was marked on the top flange of the former with black paint. At these points was also marked the number of the beam. The setting of the crossbeams was more difficult. Holes were cut through the wall wide enough to admit of their passage. They were then bedded in cement and surrounded by concrete. Before many of these were placed the contractor had started to build his blocking; where this was done in advance of the beam laying, holes were left between the crib work at all places where the crossbeams were to go. This setting of the top beams was not done until after the building was loaded. They were then run in between the bilge ways and easily placed.

During the progress of placing the steel we found the original iron support work constantly in the way. Where this was the case it was cut off. In most cases this did not weaken the existing supports. The cost of cutting this old iron was $206. A great many of these odds and ends of beams were used in place of new ones ordered for our work, and their value more than paid for what labor was done upon them; in fact, I may say where an old beam could be used and was available a new beam was not used, and, after completion of the work, the owners had for sale several tons of unused steel. It may be thought that the engineers could have fore-

seen the fact that the old beams could have been used, but it must be remembered that they were all buried several feet under the ground and their reliability was uncertain. They were carrying, or supposed to be carrying, part of the wall, and it might be unsafe to cut them out at the time they might be needed.

The loading of the building was begun January 28th, and was finished ready to raise January 19th. This was done in the same general manner as in other buildings, and the process of raising was immediately commenced, and lasted perhaps a week or ten days. There were in use between 700 and 800 jacks, each of 4 or 5 tons capacity. The maximum force used on this part of the work was about sixteen men. Each man was given charge of a certain number of jacks. At the sound of a whistle each one was given a quarter turn. The general appearance of the wall and blocking was noted, and, if all was well, this process was continued until the desired lift had been obtained. Levels were taken every day while the raising continued, the bottom flanges of the beams in the first floor being taken as a guide. Either lanterns or bicycle lamps were necessary for leveling done at this time in the cellar. In all cases the instrument was perched upon the blocking and the leveling rod inverted.

As fast as certain sections of the first floor were leveled the walls were pinned off, and, four or five days afterward, the needles were withdrawn. It is interesting to note that the heavy middle wall was the cause of much of the original settlement, and this was the only portion which gave any trouble in raising. Among other troublesome things was the necessary work around the boiler, which was accomplished without removing it from the room.

After the raising was complete, the offsets to the building were taken from the original base line. These measurements showed that the front wall is almost exactly plumb. The back wall, which was in the worst condition, is all right in spots and in places 2 inches out. The side walls are in places all right, and at the worst spots are but 2 inches out of plumb. Portions of the wall with big cracks were rebuilt.

The work was completed without injury to the workmen from falling walls and other débris, and our portion of the work was finished in April, the total cost of work under our direct supervision being about $20,000.

A great deal of credit is due to Isaac Blair & Co. for the careful and workmanlike way in which they fulfilled their contract.

It is interesting to note that more lineal feet of piles were used in the original foundations of this building than was necessary to properly carry it.

The fact most apparent from this work is, perhaps, that such piles will stand an excessive load of 35 to 50 tons if well driven and if the spacing is say 4-foot minimum.

DISCUSSION.

Mr. Henry F. Bryant.—The preceding paper has set forth the facts accurately and in considerable detail. I can add but little, but will state what seem to be the main points of interest.

This building was in such bad shape that only a few of its apartments had been occupied, and those had been vacated by order of the public officials, who felt that collapse was sufficiently near to require that the street in front should be fenced off for half its width, to prevent injury from falling walls.

This serious condition was unquestionably due to the use of too short piles, penetrating only a foot or two, if at all, into the soft sand below the peat. It is difficult to understand how architect or builder could permit such construction, but it was apparently a case where the architect, in making his contracts, had not sufficiently informed himself of the conditions to be met and had failed to exercise proper supervision of construction. The builder failed to properly watch the pile driver, who, under a lump contract, cared nothing for the quality of his work.

While in this serious condition, with the property in the hands of the mortgagee under foreclosure, and for sale for but little more than the value of the land plus the building materials, the present owners took advice from many sources regarding the possibility of repairs. Practically all advice was unfavorable except ours, and as such advice was what they desired to get, they naturally accepted it, especially as it confirmed their own opinion as experienced and conservative men.

It took some courage to do this and to clear off all the labor liens and other charges, which amounted to a considerable sum.

That the undertaking was a troublesome and dangerous one can be inferred from the statement of the contractors, Isaac Blair & Co., who have done most of Boston's difficult building moving and like work, that it was the toughest proposition they ever met.

There was a strong temptation to do this work differently; that is, to move the building to one side, put in new foundations and replace it. The expense would have been about the same but the details much simpler. What was feared was that it was impossible to support such a heavy structure on the existing filling underlaid by peat without constant settlements and cracking of walls.

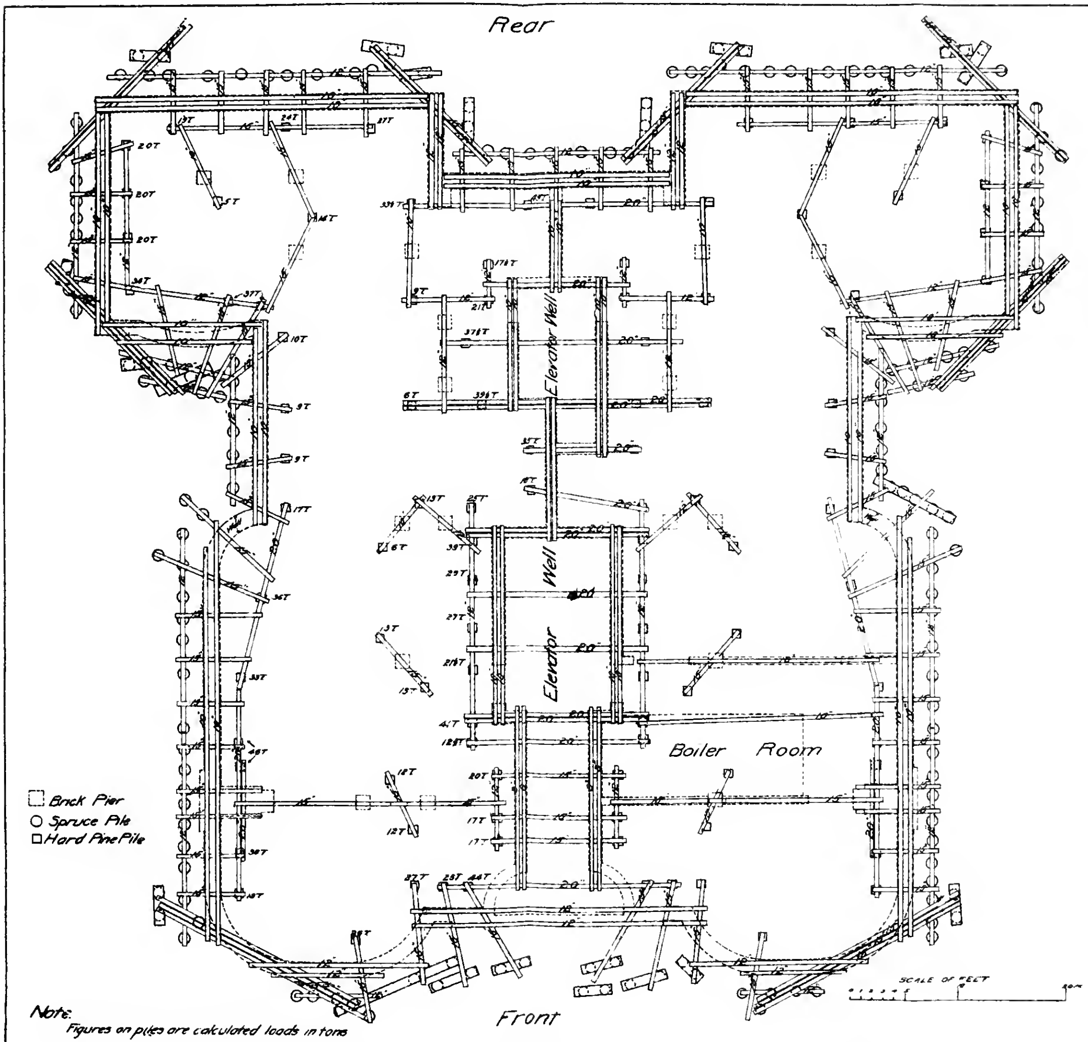


FIG. 2. PLAN OF FOUNDATIONS OF HOTEL WOLLATON, BROOKLINE, MASS.

I must say that our later work indicated much greater supporting power in the peat than was anticipated, although at no time was the whole weight on the blockings resting on fill alone.

The only uncommon features of the work were the interior heavily loaded spliced piles and the use of iron below water level in close proximity to a peat formed in brackish water.

Spliced piles must, of course, be laterally weaker than single sticks, and we endeavored to place the splices within a few feet of solid earth, either original or filled. By using squared hard-pine timber, we failed to note any evidences of anything but vertical driving in a straight line, or of the displacement of one stick from another.

The tests, which might be criticized as being only of short duration, failed to show any evidence of settlement or other motion of the interior piles, and that under very unusual loads.

We were led to attempt this loading from the collection and study of the reports of a great many from all over this country and from abroad. It became evident to us that, given a reasonably resistant soil with no underlying soft clay, loads of 75 to 100 tons could be properly placed on good sturdy spruce or Norway pine piles with proper penetration, always provided they were not placed too near to each other, and thus exceed the compressive strength of the soil.

I am sorry we were unable to get more than 70 tons on any one pile, but the building was not heavy enough or the steel beams used were too weak for anything more.

For a similar building alongside, I should be willing to drive piles to carry 20 to 25 tons, and in so doing to save money over driving shallower piles at 8 or 10 tons each.

It has been asked how long the iron beams would last under the conditions now existing. This is not easily answered, as much depends on the quality of the peat, the rise and fall of ground water and the care with which they were painted, first with red lead and then with neat Portland cement grout, and also on the porosity of the surrounding concrete.

We attempted to have the coating, both of paint and cement, well put on and free from cracks or scratches, and the concrete was quite carefully laid to absolutely surround the beam. I do not think that the ground water is likely to fluctuate much from grade — 10, or that it will contain the salts which do so much damage to steel in ordinary peat. For instance, in some of the lower levels of Boston, Brookline and probably many other

towns, lead service pipes are the only ones to be used with safety, wrought-iron and, to an extent, cast-iron disappearing rapidly.

In my judgment, the iron beams will last long enough to keep the maximum fiber stress within the elastic limit for from fifty to seventy-five years.

Moreover, it will be noted from the section, that the concrete is in most cases so disposed as to serve either as a beam or an arch between the piles and should, with the help of the old foundations, support the building indefinitely.

At this time the building has been repaired some few years, and, so far as we can learn, has shown no sign of weakness at any point.

CONSTRUCTION OF A SCHERZER DOUBLE-ROLLER LIFT BRIDGE AT MIDDLE SENECA STREET, CLEVELAND, OHIO.

By William J. Carter, Chief Engineer, City of Cleveland, Member of the Civil Engineers' Club of Cleveland.

[Read before the Club, September 8, 1903.*]

Without attempting to describe the preliminary work leading up to the adoption of a double-roller lift bridge at Middle Seneca Street, I will give a brief account of the difficulties encountered in building the bridge, principally the substructure.

On February 4, 1901, a contract was let to F. E. Gribben for the construction of the substructure of Middle Seneca Street Bridge. The Scherzer plans called for submerged counterweight pits, and indicated that the substructure was to be built in a cofferdam constructed of a single row of Wakefield triple-lap sheath piling.

After taking out the old abutments and center pier, the contractor refused to proceed unless permitted to build a double cofferdam with a clay puddle wall. This permission was refused, and the city proceeded with the work under a contract with G. Wm. Doerzbach.

At this stage the United States Government insisted that the city must secure permission from the Secretary of War for the construction of the bridge. This matter was taken up officially, and it resulted in the Government changing the location by moving the south abutment twenty-five feet into the river and setting the north abutment back twenty-five feet. This change has not been a beneficial one, as large vessels, going up stream against a very slight current, cannot avoid bringing up against the south abutment.

The foreman, in charge of the work for Mr. Doerzbach, submitted his plans for the cofferdam consisting of a single row of nine-inch Wakefield sheath piling. He also proposed to arrange a system of truss bracing that would permit the erection of a steel pit lining without having to take out cross-braces.

The borings taken showed a layer of clay five feet thick at the site of the south cofferdam, and it was decided to drive sheathing thirty-five feet long that would penetrate this layer its entire depth. The clay was also shown by the borings at about the same elevation for the north side. The work of driving the sheathing progressed without any noteworthy incident. The contractor, however, used

* Manuscript received February 27, 1904.—Secretary, Ass'n of Eng. Socs.

a peculiar method of closing his work; he would start sheathing about fourteen feet in advance of his finished work and drive from this point toward his finished work, thus making it necessary to use a closure.

This method appeared to work out first-class, but later developments showed that a worse method could not have been used, as instead of the two adjacent sheath pilings going down in the same vertical plane, invariably one was inclined at a different angle from the other, so that the closure instead of closing up the gap sometimes opened a much larger one.

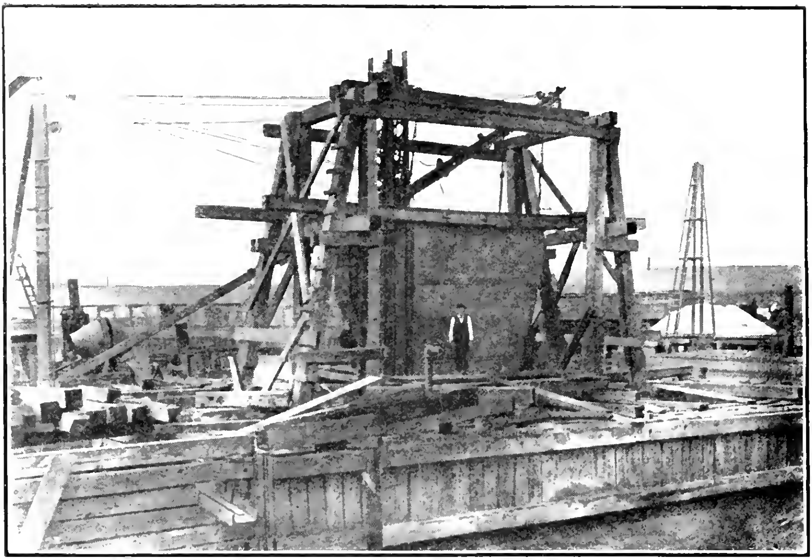
The cofferdams, as outlined, were completed during February, 1902, and an attempt was made to pump out the south cofferdam in March. After pumping two hours with a six-inch and an eight-inch centrifugal pump and only lowering the water one and one-half feet, it became evident that something was wrong. An examination of the dam was made by the diver and a serious leak found, one very large one in the rear where one of the aforesaid closures had been made. This opening was so large that the diver could walk through it.

In order to overcome this break a box was built around the effected portion of the dam and filled with concrete. The smaller leaks were calked up and pumps again started.

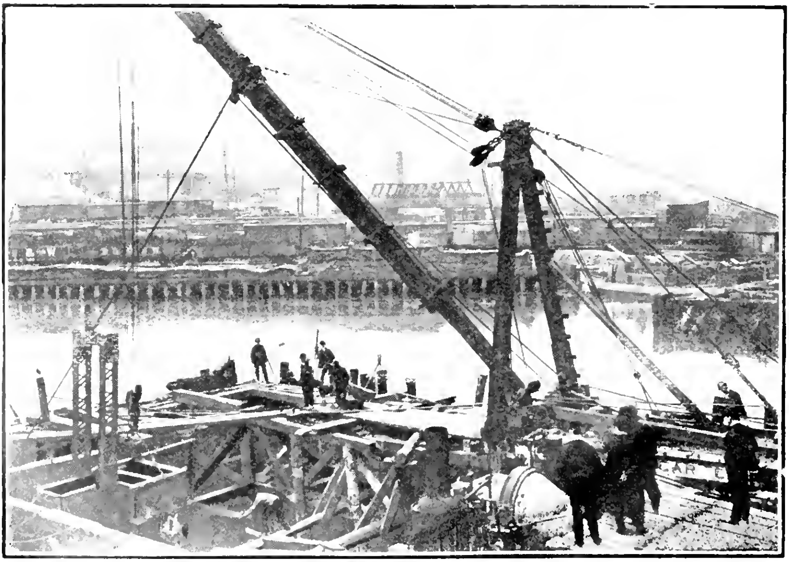
The water, however, broke through the box apparently coming under the bottom. At this time some additional borings were made to see whether we had the clay penetration figured upon and it was found that the clay was about seven feet lower than originally supposed. So it was necessary to surround the first cofferdam with sheathing forty-five feet in length. This was done, and in order to transmit the water pressure to the inner bracing, the space between the two sets of sheathing was filled with concrete. In driving this outer sheathing at a few points around the dam, obstructions were encountered, that seemed to be in the nature of logs, some of them at a depth of about fourteen feet below the river bottom.

On June 4th, the pumps were again started and the water lowered about eight feet, when the second set of bracing was put in place. The water was then lowered thirteen feet, when a bad hole opened up in the northwest corner at a point where a submerged log interfered with the driving of the outer sheathing. This break was so serious that our pumps were unable to cope with it.

The formation above the clay was coarse sand and gravel for several feet; above this, quicksand and then the river silt. It was thought that, by injecting cement grout, this stratum of



Pit Lining, South Abutment, Ready to Lower.



Setting Pit Lining, North Abutment.

South Arm Erected.

gravel and sand might be solidified around the points where submerged logs had been encountered in driving the outer sheathing.

Some inch and a quarter piping was secured and driven down until the clay stratum was penetrated. A plug in the end of the pipe served as a shoe for the pipe and afterward was driven out with a rod. The pipe was then raised about six inches at a time, the cement grout being pumped in with a small force pump. This method of injecting grout was used at each point where we had encountered submerged logs. Pumping was again attempted, but satisfactory progress was not made, so we decided to deposit a five-foot layer of concrete over the entire bottom with the exception of the spaces occupied by counterweight pits, these spaces to have the concrete excluded by building a form around them. This layer of concrete was deposited through the water by means of a spout, the concrete being mixed in a Smith concrete mixer, with sufficient water to make a good mortar, and handled by means of a wheelbarrow to the spouts, the bottom of the spout being within a foot of the foundation. The spout was gradually raised as the material filled up. The five-foot thickness was made up in three layers, the surface being regulated by means of soundings so that the layers were comparatively level. Grout was injected into the spaces to be occupied by the counterweights. After the cement had set for five days, the pumps were started and the surface of the concrete uncovered.

The original leak in the rear of the cofferdam now made its appearance through the spaces left for the counterweights. After several ineffectual attempts to stop this leak it was decided to build the steel pit linings above their respective pits and lower them into position, building concrete around them, using the diver to deposit the same, and ram the concrete into place.

The bridge company objected to using this method of placing the pit linings for fear that, on account of the small clearance for the counterweights, it would be impossible to secure good enough alignment, but after having been assured that the city would assume all risks they proceeded and had the pits lowered into place, when they were concreted. After five days the pit was pumped out without any further trouble and kept clear by means of a four-inch pulsometer.

In clearing up the counterweight pits prior to lowering the steel linings in place, some of the effects of the injected grout appeared. It was necessary to excavate about two feet in each pit to get the proper amount of concrete deposited beneath the pit linings. In making this excavation layers of cement rock were en-

countered that had to be blasted to remove the same. These layers were just as natural as the sand formation showing that the grout had penetrated to good effect. Whether this was the case in all points, I am unable to state.

The north cofferdam, being nearer inshore, made it possible to surround the front and two sides with an outer row of sheathing forty-five feet in length, and not drive any in the rear. An examination of this sheathing by the diver before the pumps were started showed several places where breaks had occurred, but none of these breaks were at a point over six feet above the river bottom. It was thought that if clay was deposited along the outer face and two sides of sufficient depth to extend same above this six-foot point that all of these openings could be effectually stopped, and this was done.

The six-inch and eight-inch centrifugal pumps did not work very satisfactorily in pumping out the south cofferdam after they had to work under head of from twelve to fourteen feet. Just about the time the pumps succeeded in lowering the water to the concrete that had been previously deposited, the large pump would lose suction, sometimes taking from one-half to three-quarters of an hour before the same could be put in operation, permitting the water to rise a couple of feet all over the cofferdam.

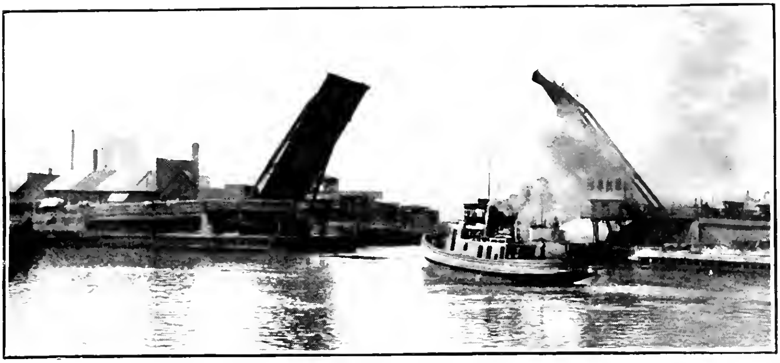
For this reason I decided to use a ten-inch submerged centrifugal pump on the north side of the river. This pump was mounted in a framework made up of four 6 x 6 timbers, securely braced and of sufficient length to reach the bottom of the pit when excavated.

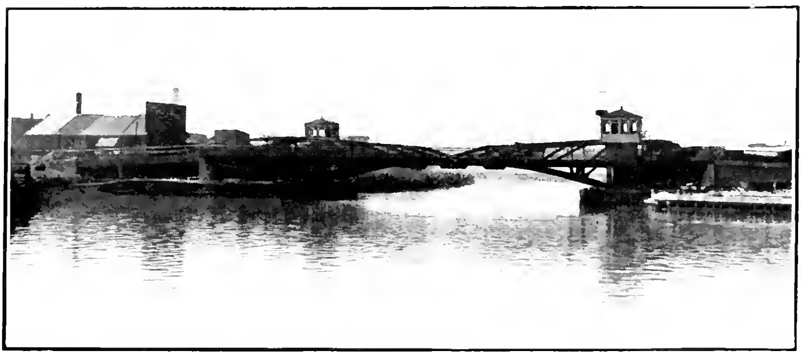
This pump was lowered into position and operated with a 30-horse-power horizontal engine. Our first attempt to pump out the north dam was successful with such a pump in about two hours. One leak developed in the west side of the dam that seemed to indicate trouble, but a couple of scow loads of clay dumped opposite this point effectually stopped the leak. There was so little leakage after this that it was impossible to operate the ten-inch pump, so the pit was kept free by means of the six-inch Nye pump.

The work of clearing out this pit and putting in the concrete progressed without any unusual difficulties.

The pit linings on this side of the river were built on the dock and lowered bodily into place, this being made possible on account of having used truss bracing, leaving a clear space for the pits.

The superstructure was designed for a one-hundred-and-twenty-foot clear channel, the truss design giving somewhat the appearance of an arch by using the curved bottom chord, the top chord meeting the same at the center of the river. The chord of one arm





was open and that of the opposite arm was finished wedge shape, the wedge entering the opposite chord, when the two arms are lowered into place. The counterweight is placed in the end triangular panel, the castings being bolted on either side of a web plate. These counterweights, when the bridge is open, rotate into the pit, the bottom of the weight at the lowest point being about eighteen feet below the surface of the river.

No difficulty has been encountered in operating the bridge, even if pit linings are filled with water.

The bridge is operated by means of two 25-horse-power electric motors on each arm. It takes from 78 to 84 amperes to raise the arm and from 45 to 60 to lower it; the bridge can be opened in one minute and closed in forty-six seconds. The controllers are similar to those used on the street cars. Provision has been made so that one operator can operate both arms; this is only to be done in case of an emergency, each arm being operated independently.

A system of signal lights in the operator's house indicates the exact condition in which the bridge is placed. The first notch operates the breaks and pulls out the tail locks. The second notch starts the bridge in motion.

When the bridge has been lowered, the proper connections made and everything locked, the signal lights go out. Should any one of the operations be neglected, the lamps continue to burn.

After many little vexatious delays, this work having extended over a period of two years, it was very gratifying to lower the two arms and have them fit perfectly.

The superstructure weighs 416.28 tons, exclusive of counterweights, the counterweights amounting to 227.31 tons.

The lumber in flooring, 40,000 feet B.M.

I believe one thing that has been brought out with more force than anything else during the construction of this bridge has been not to build a bridge with submerged counterweights. About all the trouble that was encountered could be attributed in some way or other to these submerged counterweight pits.

The bridge is of the Scherzer design. It cost, including a $5000 royalty, $74,277.99 for substructure and $63,096.65 for superstructure.

This bridge has been in service since June 25th and works well.

THE LACKAWANNA AND WYOMING VALLEY RAILROAD.

By George B. Francis, Member of the Boston Society of Civil Engineers.

[Read before the Society, January 14, 1904.*]

This project was conceived in 1900 by parties having interests in the northern anthracite coal region, who believed that there was need of better freight and passenger service for the local requirements, and that a first-class interurban electric railroad from one end to the other of this coal field would prove to be a good investment.

The Lackawanna Valley, in which flows the Lackawanna River, a branch of the Susquehanna River, is a continuation of the Wyoming Valley, in which flows the Susquehanna River, the latter river breaking through the northern boundary ridge of the valley at Pittston, a point near the center of the coal measures.

These valleys are in the Alleghany Mountain region of the northern part of the State of Pennsylvania.

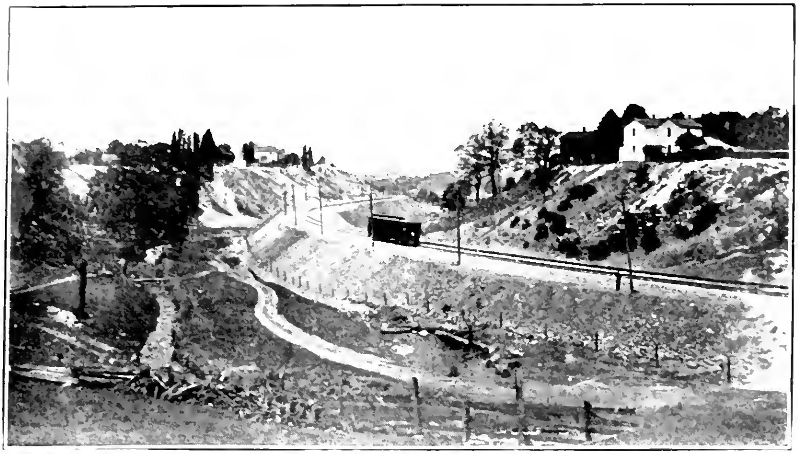
The three coal fields known as the southern, middle and northern anthracite coal fields of Pennsylvania are the only anthracite coal fields deserving of mention in the United States, and the demand for this coal comes from all points of the compass. The area of these fields is the equivalent of a tract of land twenty-two miles square. These coal measures were once horizontal and bituminous, but the volatile elements of sootiness and gas have been driven off under the great heat and pressure to which they were subjected when the Alleghany Mountains were uplifted.

This coal was discovered between 1770 and 1790, at the time of the Revolutionary War, by a party of hunters, but was not mined until 1807, and mining was not developed as a trade until 1820.

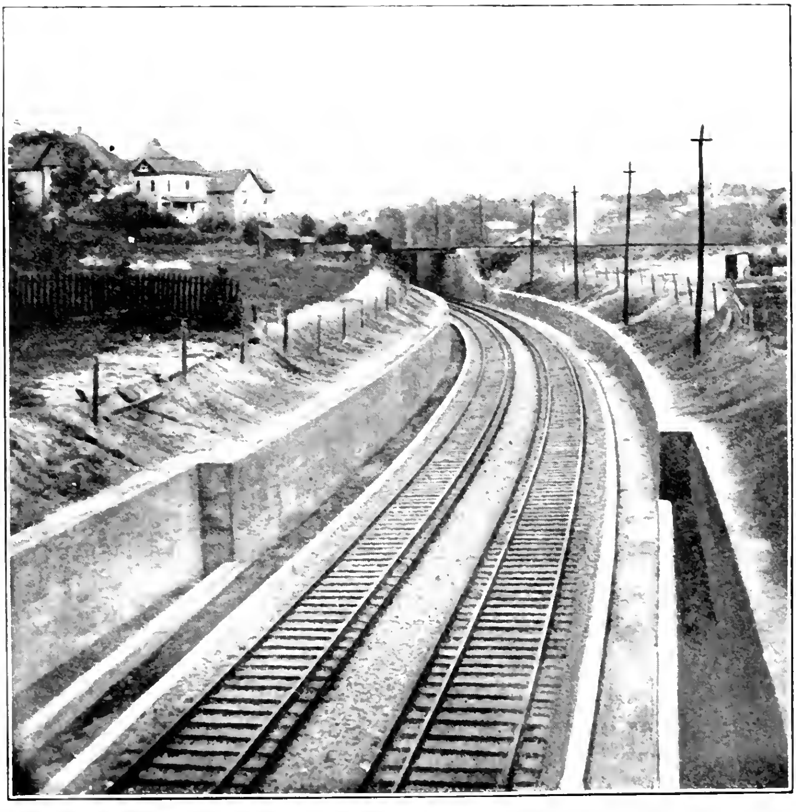
The northern coal field extends from Carbondale, on the northeast, to Nanticoke, on the southwest, a distance of about fifty miles. At Carbondale, the coal lies near the surface, and at Nanticoke, in some veins, as deep as eighteen hundred feet, and there is yet much coal to be mined.

Scranton and Wilkesbarre lie twenty miles apart, near the center of the coal fields. These cities, together with the intermediate territory, provide a population of upward of 200,000 people adjacent to the railroad to be described.

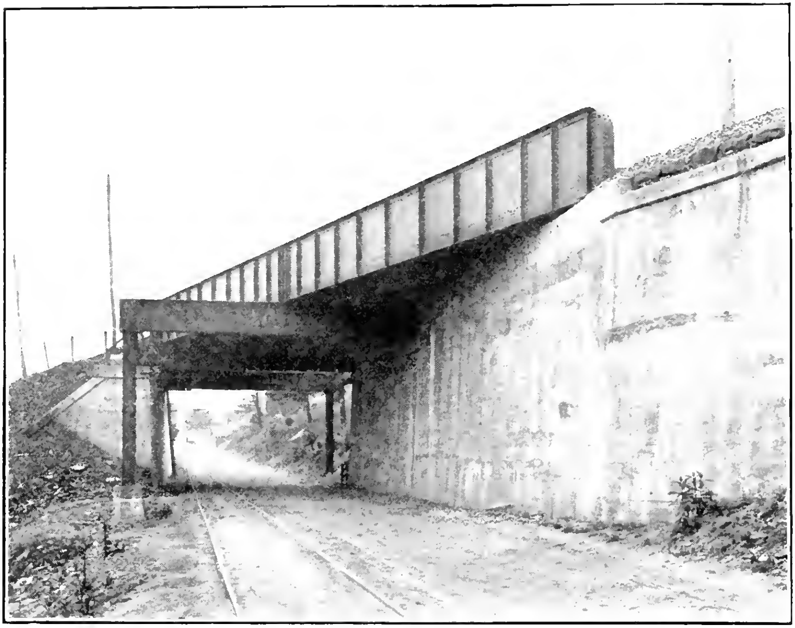
* Manuscript received March 3, 1904.—Secretary, Ass'n of Eng. Socs.



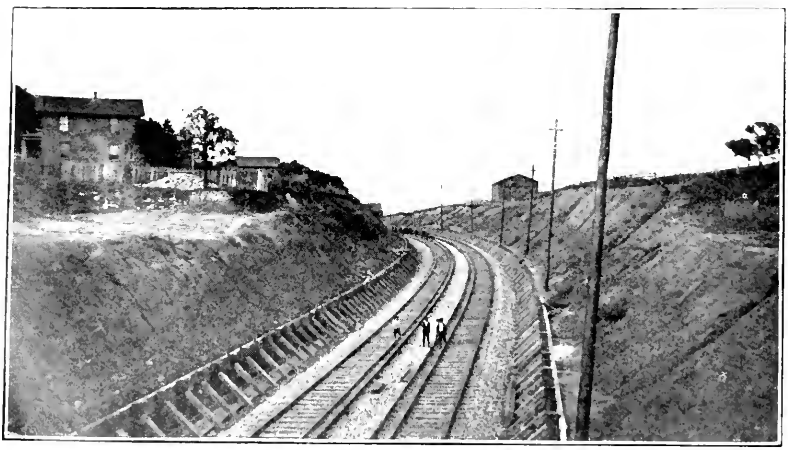
TRACK VIEW, PITTSTON RAVINE



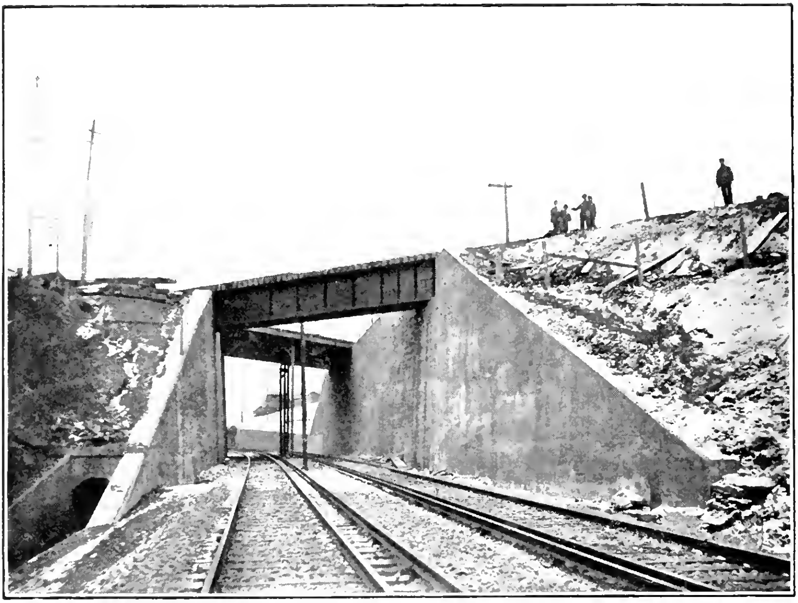
NOLAN STREET RETAINING WALLS. ERIE RAILROAD BRIDGE IN DISTANCE.



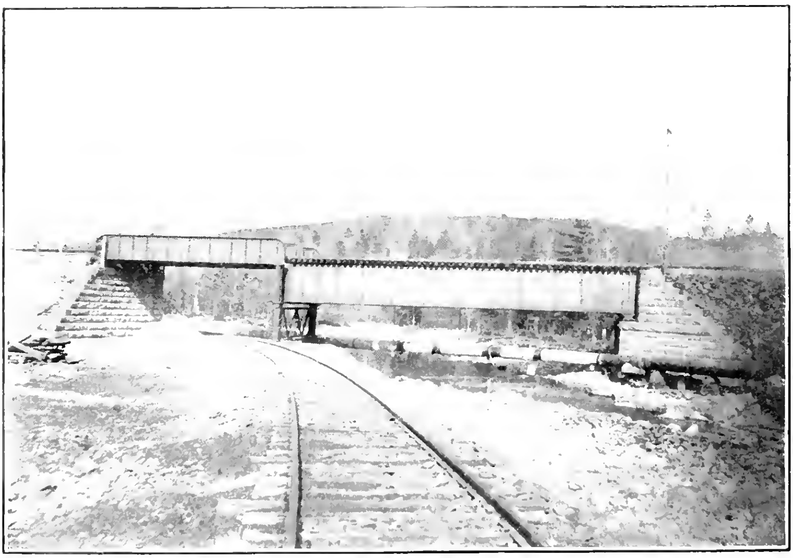
Heidelberg Bridge.



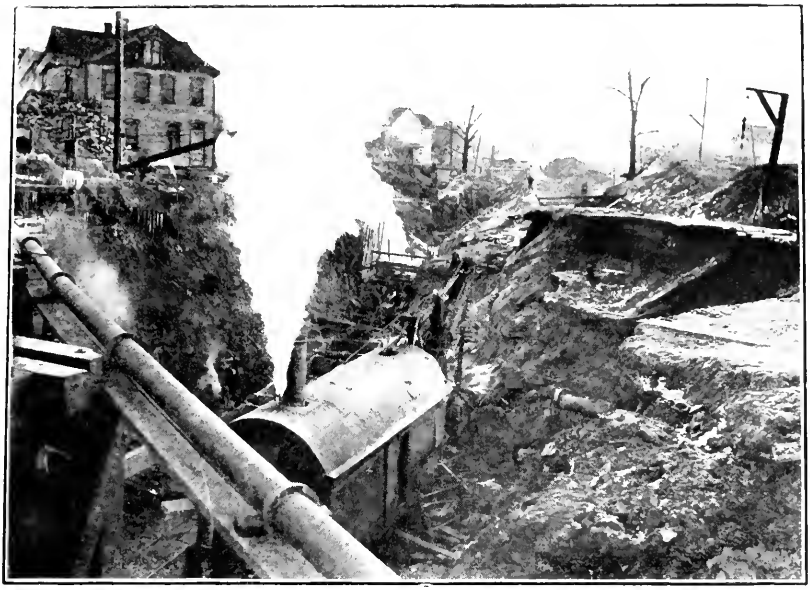
Brattice Work. Swoyer's Hill Cut.



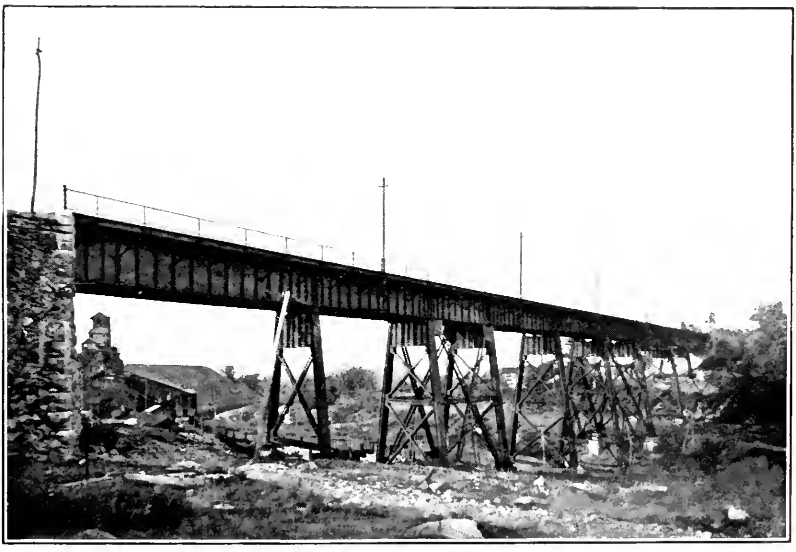
Broad Street Bridge, Erie Railroad.



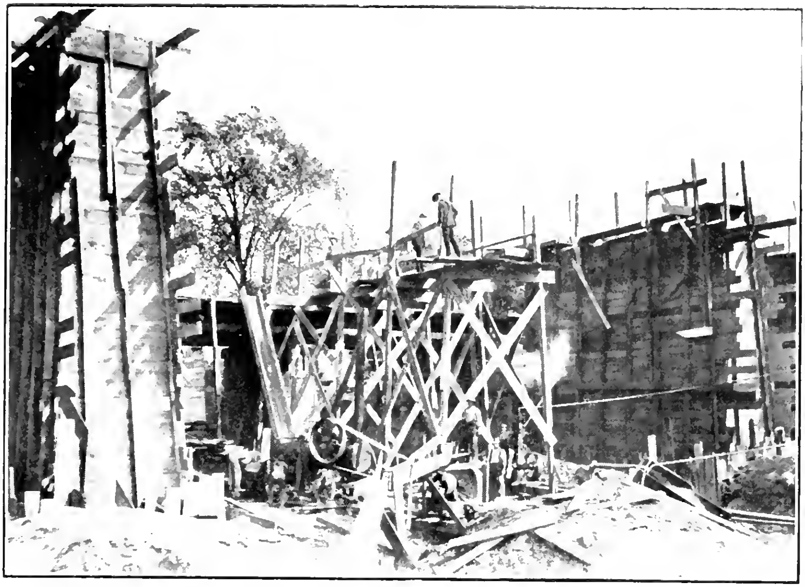
Spring Brook Bridge.



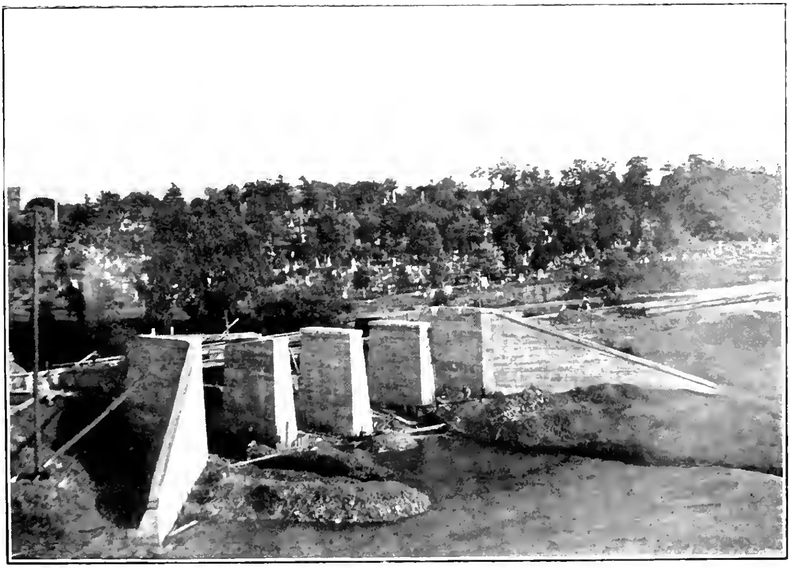
Cut, Broad to William Streets, Pittston.



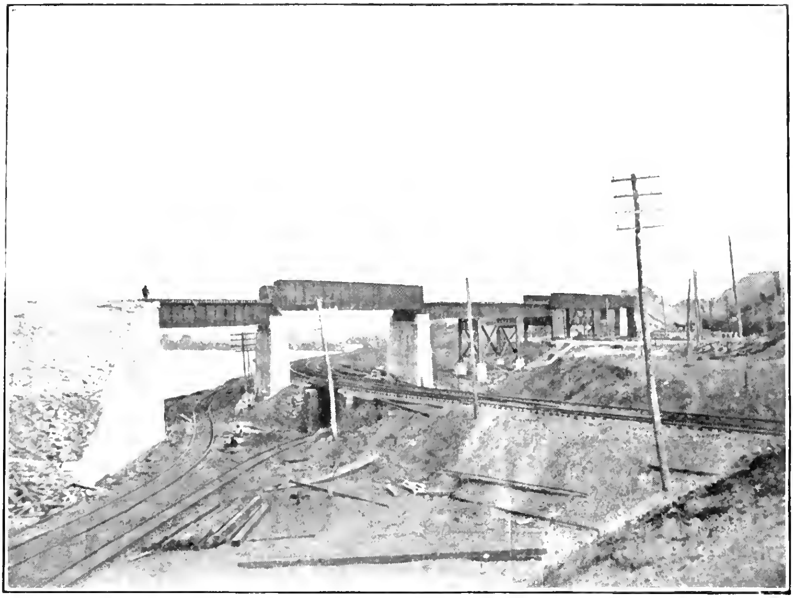
Avoca Viaduct.



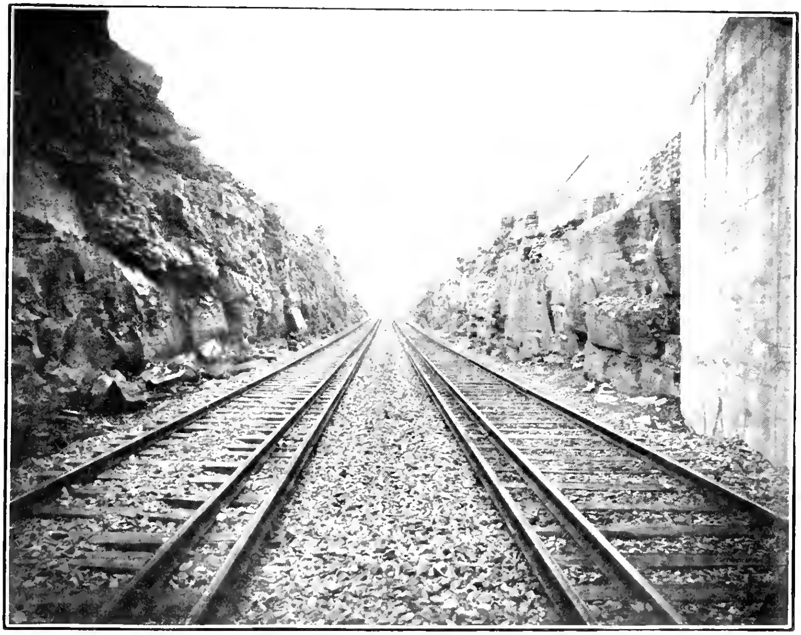
Mill Creek Bridge Showing Forms for Concrete.



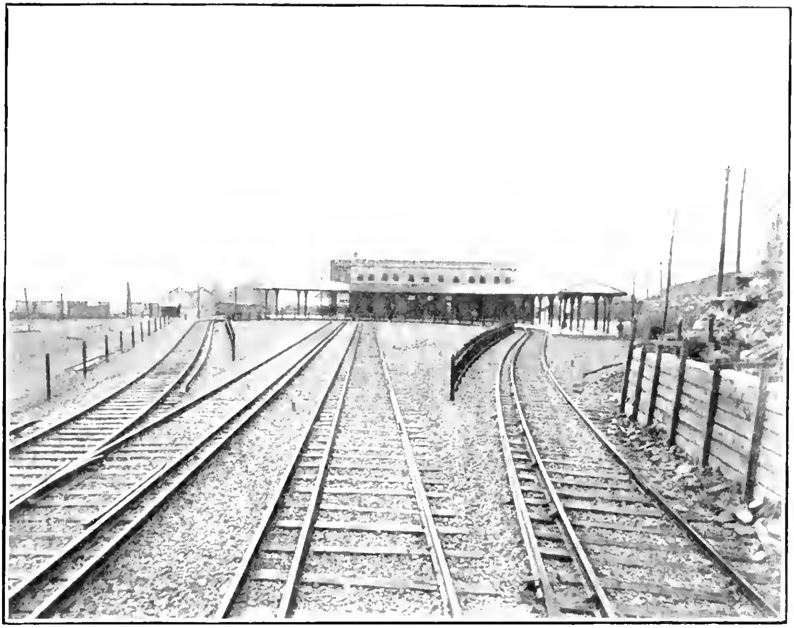
Mill Creek Bridge, Abutments and Piers; Showing Concrete Stripped of Forms.



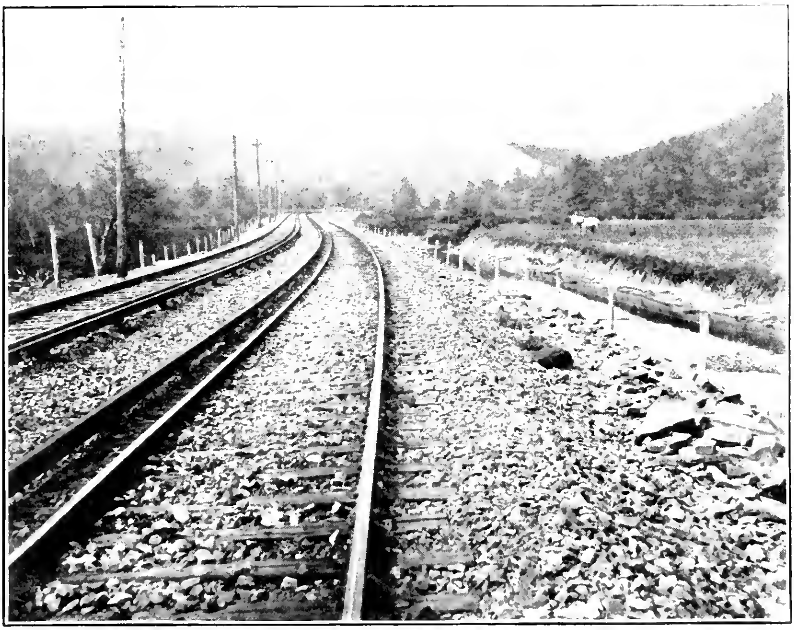
Prospect Viaduct.



Rock Cut, Moosic.



Scranton Terminal. Loop and Shelter.



Track View. Meadow Brook Valley.

Owing to the coal transportation, several railroads have been built to and through these valleys, as follows:

The Lackawanna Railroad,*
The Lehigh Valley Railroad,* †
The Erie Railroad,‡
The Delaware and Hudson Railroad,
The Ontario and Western Railroad,
The Central Railroad of New Jersey,
The Pennsylvania Railroad.

The street railways in the valley also extend from Carbondale to Nanticoke.

This explanation of the railroads and coal measures is necessary as a preliminary to show why the Lackawanna and Wyoming Valley Railroad was so expensive to build and why it required so many different kinds of structures.

The railroad now to be described, which has been built under steam-railroad charter and which is now being operated, extends from Wilkesbarre to Scranton, a distance of about twenty miles.

It is a standard-gauge, double-track, rock-ballasted, third-rail electric road on a private right of way throughout its length, laid with 90-pound rail.

It was opened for business from Scranton to Pittston in May, 1903; from Pittston to Hancock in September, 1903, and from Hancock to Wilkesbarre in December, 1903. Later on, it is expected that the road will be extended to Carbondale.

The railroad enters Scranton by a temporary location, known as the Erie cut-off, with steep grades (4 per cent.) over a hill that is to be pierced by a double-track tunnel.

Except on the temporary cut-off above noted, and at the terminal loops in Scranton and Wilkesbarre, used only for passenger service, the alignment is within the limits of good practice for steam railroads of the first class.

With the exception of the temporary cut-off above noted, the profile of grade line of the track is as good as those of the steam railroads in the same mountain region, the maximum rate being 2 per cent.

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* The Lehigh Valley and the Lackawanna are trunk-line railroads between New York City and the West, passing through this coal region.

† The Lehigh Valley Railroad controls the Pennsylvania and New York Canal and Railroad.

‡ The Erie Railroad controls the New York, Susquehanna and Western Railroad, the Erie and Wyoming Valley Railroad and the Wilkesbarre and Eastern Railroad.

The track, including rails, ties, ballast and switches, is of first-class standard steam-railroad construction; in fact, equal to the best existing construction.

In addition to the passenger traffic, it is intended that the road shall serve as a freight road for the interchange of bulk freight between the steam roads entering one end of the valley and not reaching the other, of which there are several. A local freight service has also been inaugurated.

Beginning with the terminal station at Wilkesbarre, the physical characteristics are described as follows:

The Wilkesbarre Terminal is in the heart of the city, on the opposite side of North Market Street from the Union Station of the various steam roads. Here is a capacious terminal passenger-station building, costing in the neighborhood of $50,000; also freight house and freight yards. The tracks lead out of the city by way of the old Pennsylvania and New York Canal and Railroad Company right of way, purchased and leased from the Lehigh Valley Railroad, to the bank of the Susquehanna River. Along the bank of this river are constructed three timber cribs, about 30 feet high and aggregating 1800 feet in length.*

Mill Creek Bridge, at the city line, has been built in several spans, supported on concrete masonry, according to the terms of the right-of-way agreement. The tracks then pass under a bridge span of the Wilkesbarre and Eastern Railroad, which bridge span has been entirely rebuilt to give sufficient head room.

Near the New Prospect Breaker, a viaduct has been constructed, 554 feet in length and about 800 tons weight, to carry the road over the two Harvey's Lake Branch tracks, the four main tracks of the Lehigh Valley Railroad, the mine tracks of the Lehigh Valley Coal Company, the highway upon which is the track of the Wilkesbarre and Wyoming Valley Traction Company, and the three tracks of the Central Railroad of New Jersey.

At this point a mine-opening bridge has been built for the relocated highway. Various retaining walls and pipe subways have been built here; also a pump house and gas-tank building have been relocated and built.

Several bridges have been built for the crossing of highways in the next few miles, as follows:

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* Described and illustrated by the author, in "Timber Crib Construction," JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, vol. xxxii, No. 2, February, 1904.

Port Bowkley Road,
Hancock Avenue,
Haley's Road,
Saylor Road,
Inkerman Road.

At Swoyer's Hill cut it has been necessary to build timber brattice work on both sides of the cut for 900 feet in length, to keep the blue clay from sliding on to the track. The timber struts extend under the tracks from side to side each 5 feet.

A bridge has been constructed over the Erie Railroad track, as well as other bridges for Erie Railroad mine tracks, just westerly of Pittston.

In entering Pittston from the west it has been necessary to build retaining walls of considerable length, and to build a bridge at Nolan Street, a bridge for the Erie Railroad and a bridge for Plank Street to pass over the railroad.

In the city of Pittston a three-track through plate-girder bridge of about 90-foot span has been built over Main Street.

Another three-track bridge has been built over Railroad Street.

Both a passenger and a freight station have been constructed at Pittston.

A large culvert was built in the ravine going out of Pittston on the north.

Heavy retaining walls were built between Broad and Williams Streets, Pittston; also a bridge over the tracks for both these streets, as well as a bridge for the Erie Railroad over the tracks near Broad Street.

At Heidelberg, a bridge was built for the railroad over the street and the street railway.

A viaduct about 600 feet long was built at Avoca over the tracks of the Lehigh Valley Railroad and the Delaware and Hudson Railroad, a highway and a street railroad. This viaduct was for the purpose of crossing from one side of the ravine to the other. It contains about 1300 tons of steel.

Another bridge was built over Plane Street, Avoca. Near this place, as well as at several other places, it was necessary to go into the mine workings and build masonry to support the abutments of bridges where the roof of the mines was so thin that there was danger of its caving in.

At Moosic, the tracks pass under another bridge (which was built to carry the Erie Railroad) in a deep rock-cut.

At Spring Brook, Moosic, two bridges have been built to carry the tracks over a highway, a branch railroad and Spring Brook.

The railroad then passes through Meadow Brook Valley on easy grades.

The passenger station at Scranton is a substantial brick building, which has cost about $50,000. It contains the main offices of the company and is located near the center of Scranton. The terminal site contains about 100 acres and was formerly the location of the north works of the Scranton Iron and Steel Company, now removed to Buffalo.

The passenger station has a loop track of 60 feet radius, the same as at Wilkesbarre.

The freight house at Scranton is a substantial building, so arranged that it can be enlarged as needed.

The problem of securing terminal lands in the heart of Scranton, Pittston and Wilkesbarre, as well as securing right of way through the coal lands and workings, was a stupendous one, and only through the utmost patience and perseverance was it accomplished.

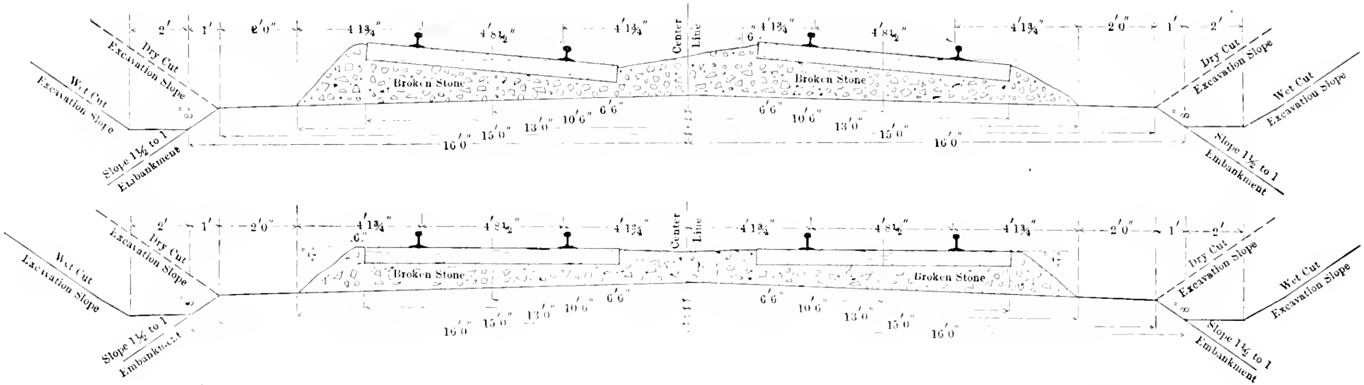
In Scranton, it was solved through the moving of the Lackawanna Iron and Steel Company to Buffalo, which threw a large area of land into the market.

In Pittston, a long strip of land through the center of the city was secured from the Pennsylvania Coal Company, but before the transaction was completed the coal company came under the control of the Erie Railroad Company, and it was many months before the stipulations of construction, etc., could be reduced to an agreement and the agreement signed.

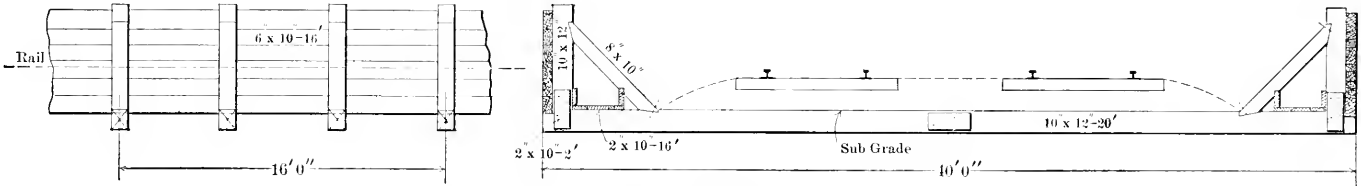
In the approach to Wilkesbarre, the right of way traversed lands of individuals who had leased surface and mining rights to the Wyoming Coal Company, Lehigh Valley Coal Company, Lehigh Valley Railroad Company, Central Railroad of New Jersey and the Pennsylvania and New York Canal and Railroad Company, as well as lands owned by these various companies. The right of way also interfered with streets, city railroad tracks, culm banks, mine workings, gas works, pump houses, etc.; but, after hard labor on joint surveys, consultations, tentative agreement papers and infinite patience by all concerned, the vexatious problems were solved, one after another, and the road built.

The terminal site in Wilkesbarre involved the purchase of several acres of improved property and the exercise of much ingenuity and tact to secure the willingness of the owners to part with their property and at the same time avoid being compelled to pay extremely high rates.

At various other places much difficulty was experienced in



STANDARD TRACK SECTIONS FOR DOUBLE TRACK, LACKAWANNA AND WYOMING VALLEY RAILROAD.



BRATTICE-WORK CRADLE, SWOYER HILL CUT.

BILL OF MATERIAL FOR 16-FOOT PANEL.

	Ft. BM.		Ft. BM.
6 pieces sills, 10 x 12, 20 feet	1200	10 pieces flume, 2 x 10, 16 feet	267
6 " posts, 10 x 12, 5 feet 4 inches	320	9 " plasters, 2 x 10, 2 feet	30
3 " braces, 8 x 10, 12 feet	240	24 boat spikes, ½ x 8.	3017
12 " lagging, 6 x 10, 16 feet	960	32 20d nails.	

securing right of way, and resort was had many times to condemnation proceedings.

With the exception of the freight and passenger stations at Wilkesbarre, Hancock, Pittston and Scranton, the stopping points consist of platforms on each side of the tracks, with small shelters. There are no ticket agents excepting at the four places named above.

As a rule, the stopping places are at under or over-crossings, and the crossing of tracks at grade and the breaking of the third rail are avoided. There are, however, a few exceptions to this rule.

Nearly all the masonry required for retaining walls, bridge abutments and culverts has been constructed of Portland cement concrete, and the following is extracted from the specifications for such work:

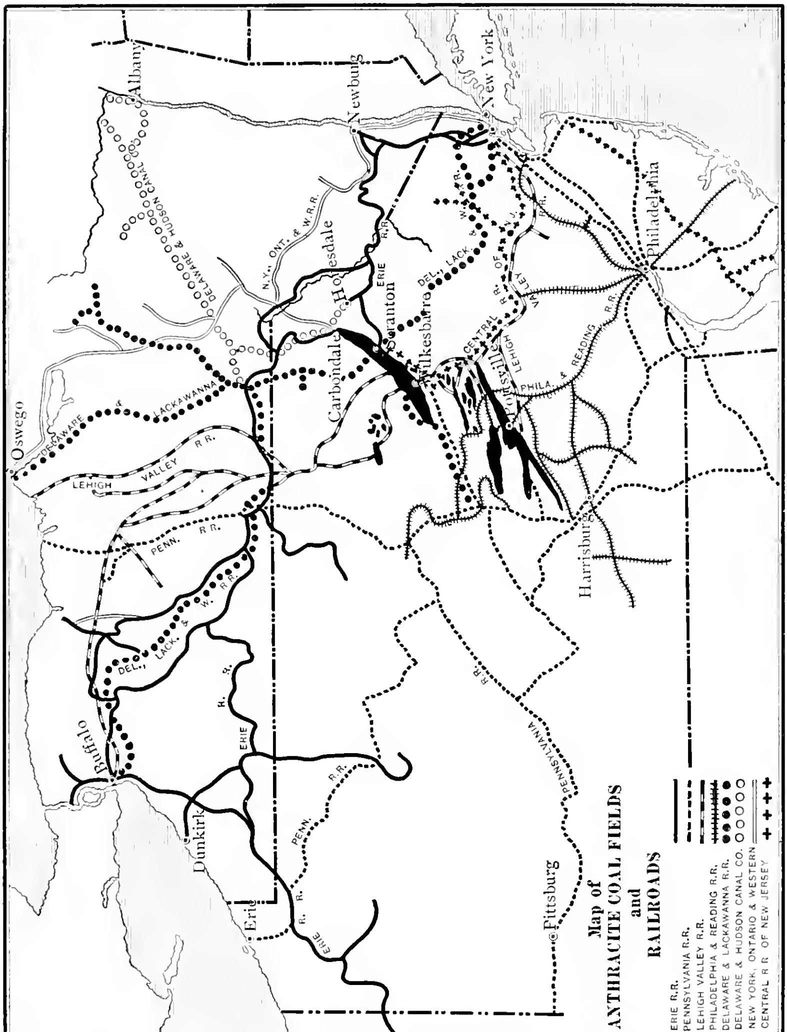
Extracts from Concrete Specification.

Concrete for the bodies of piers and abutments, for all wing walls for same and for the bench walls of arch culverts shall generally be made in the proportions (by measure) of one (1) part of cement to three (3) parts of sand and six (6) parts of crushed stone. In foundations and arches, proportions will vary according to instructions from the engineer.

All concrete must be mixed on substantial platforms of plank or boards securely fastened together, so that the various materials of the concrete can be kept entirely free from admixture of foreign matter; mixing on the ground will not be allowed under any circumstances. Satisfactory methods of measurement will be the use of headless and bottomless barrels or boxes boxes preferred) for measuring sand and broken stone. The measurement of sand and broken stone in the ordinary shallow, round-bottom wheelbarrow will not be considered satisfactory and shall not be permitted.

Molds of substantial character shall be made in which to construct all concrete work. The material for these shall be furnished by the contractor, and the expense of furnishing all such material and of constructing and of removing the same shall be covered in the price per cubic yard paid to the contractor for the several classes of concrete work called for. The face of all plank for molds shall be dressed on one side, and all plank used on the front surface shall be of a uniform thickness, and usually two and three-fourth (2¾) inches in thickness, for all important work, and the frame holding them in place shall be of sufficient strength so that they shall be practically unyielding during the progress of filling, tamping, etc. The frame work may be fastened together either by heavy wires or iron rods (in most cases wire will be preferred).

In case rods are used, a sleeve nut will be provided on the front end so the rod will not project through the face of the concrete when completed, and at least two inches short, so the hole can be filled with cement; the uprights or studding shall be placed not more than four (4) feet apart, and well cross-wired or rodded, so there will be no possible chance of their giving away. Foundation concrete may be put into excavations without the use of molds, provided the sides of the excavations are reasonably true and the material is sufficiently firm, so that the concrete may be rammed



MAP OF ANTHRACITE COAL FIELDS AND RAILROADS.

thoroughly without yielding to the adjacent earth. The top of all foundations shall be finished smooth and level, the corners and edges being thoroughly rammed and compacted and the whole surface filled full of mortar. No honeycombed surface will be allowed. When anchor bolts are required, they shall be set in place and held firmly as to position and elevation by templates securely fastened to the mold and framing.

The bridges have been built under the specifications known as "Cooper's E 40."

On account of the exposure of the live third rail, the entire right of way has been fenced with wire fencing, and trespassing on the same is thereby nearly done away with.

The equipment consists essentially of the following kinds of cars, etc.:

One locomotive,

Ten single-end passenger cars (controller on one end only), divided in the middle for smoking compartment,

Three single-end combination cars, for passengers and baggage,

Four single-end express cars, for local package express,

Fifteen double-end multiple-unit cars,

Ten ordinary box freight cars and a repair car.

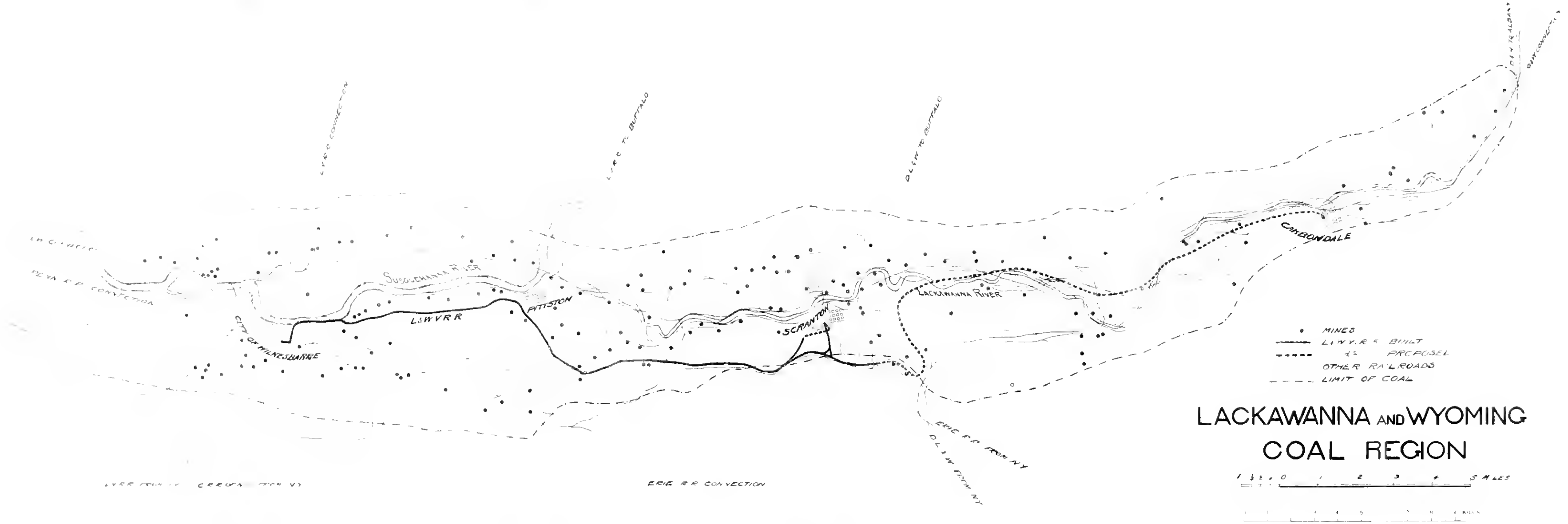
The passenger cars are electrically heated and lighted, are 52 feet long over all and have steam railroad trucks, equipped with two 150-horse-power motors.

The car house, shops and power house are located on the terminal land at Scranton, alongside of Roaring Brook, a tributary of the Lackawanna River.

The car house is 177 feet long and 146 feet wide, and is 28 feet 6 inches high in the clear. It has two division fire walls, and each of the three divisions contains three tracks. One bay contains track pit and repair-shop conveniences. The building is fireproof throughout. The walls are of brick, the roof of steel trusses, with concrete and expanded metal for covering. The repair portion of the building is divided into blacksmith shop, machine shop, winding room, tool room, office, etc. It is lighted by electricity and heated by hot water.

The power house is 90 feet wide, 133 feet long and 42 feet high. The boiler room, which is separated from the engine room by a brick wall, is 42 feet wide and 26 feet 6 inches high. There is room for seven 400-horse-power Babcock & Wilcox water-tube boilers, of which five are installed. These boilers are equipped with Roney mechanical stokers.

The coal and ashes are handled mechanically, by conveyor, through overhead bunkers and stokers, to fire, and then, as ashes, in an ash car running on a track beneath the boilers.


SUSQUEHANNA RIVER
PITTSTON
L&WVRR
CITY OF WILKESBARRE
SCRANTON
LACKAWANNA RIVER
CARBONDALE
L V R R TO BUFFALO
D L & W TO BUFFALO
ERIE R R CONNECTION
ERIE R R FROM N Y
D L & W FROM N Y
MINES
L & W V R R BUILT
do PROPOSED
OTHER RAILROADS
LIMIT OF COAL
LACKAWANNA AND WYOMING
COAL REGION
5 MILES

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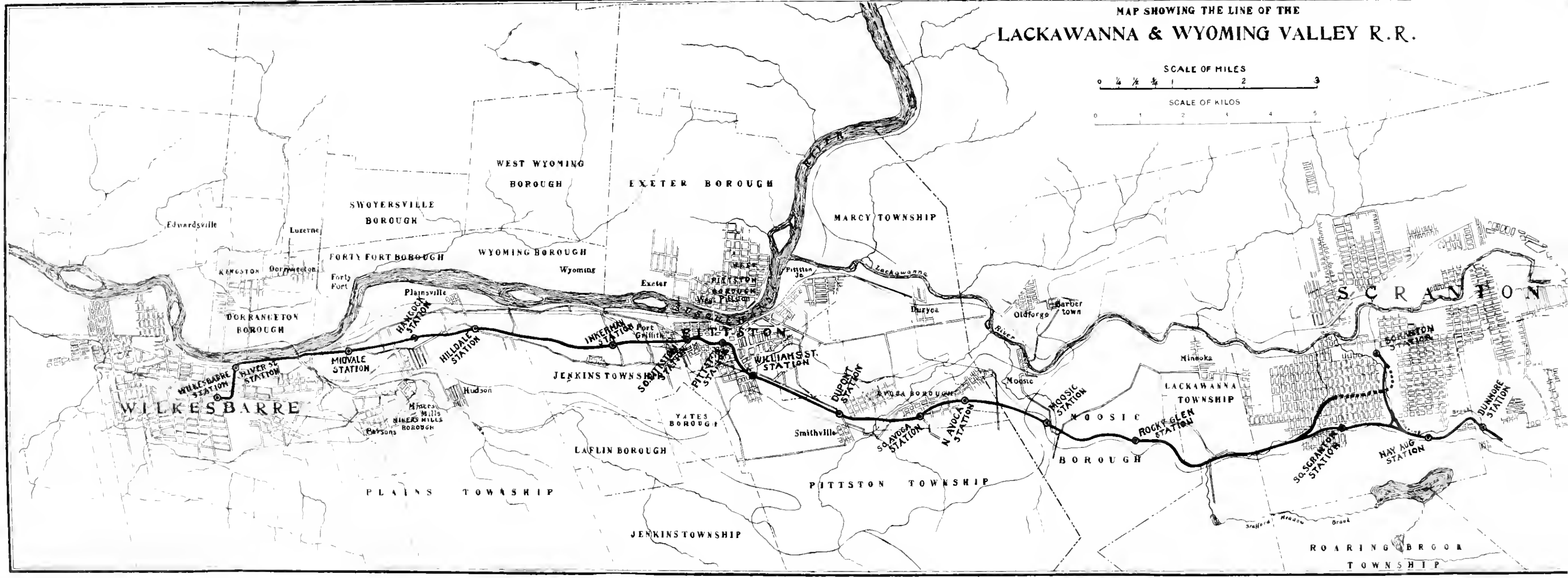
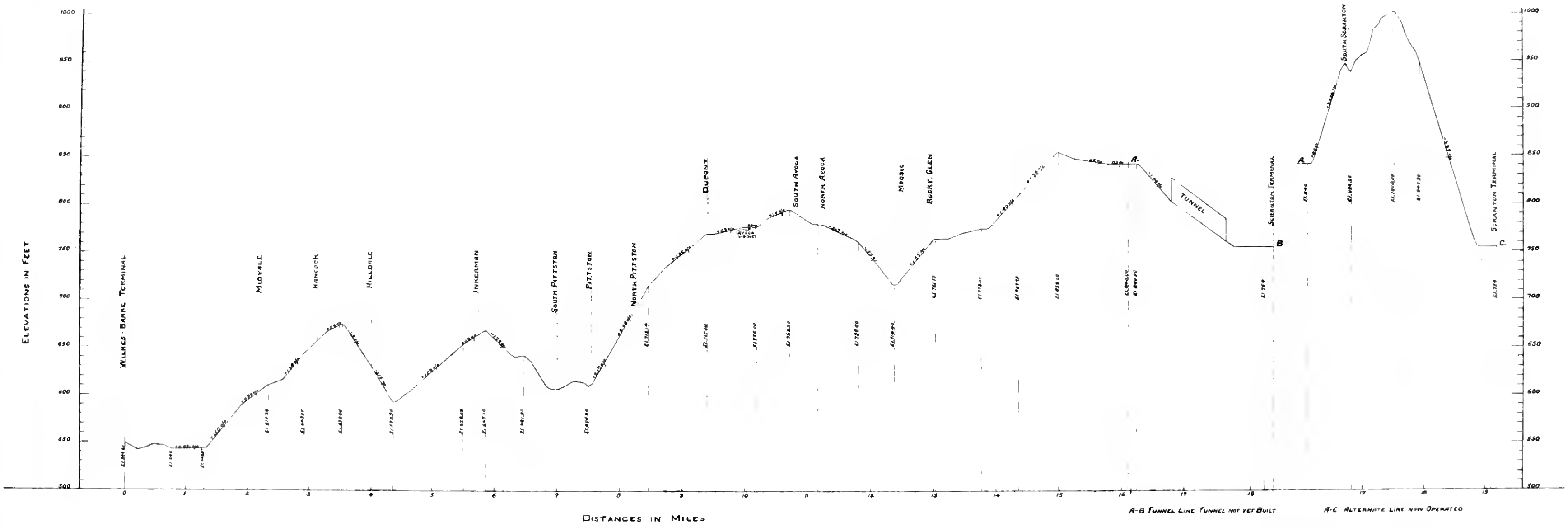
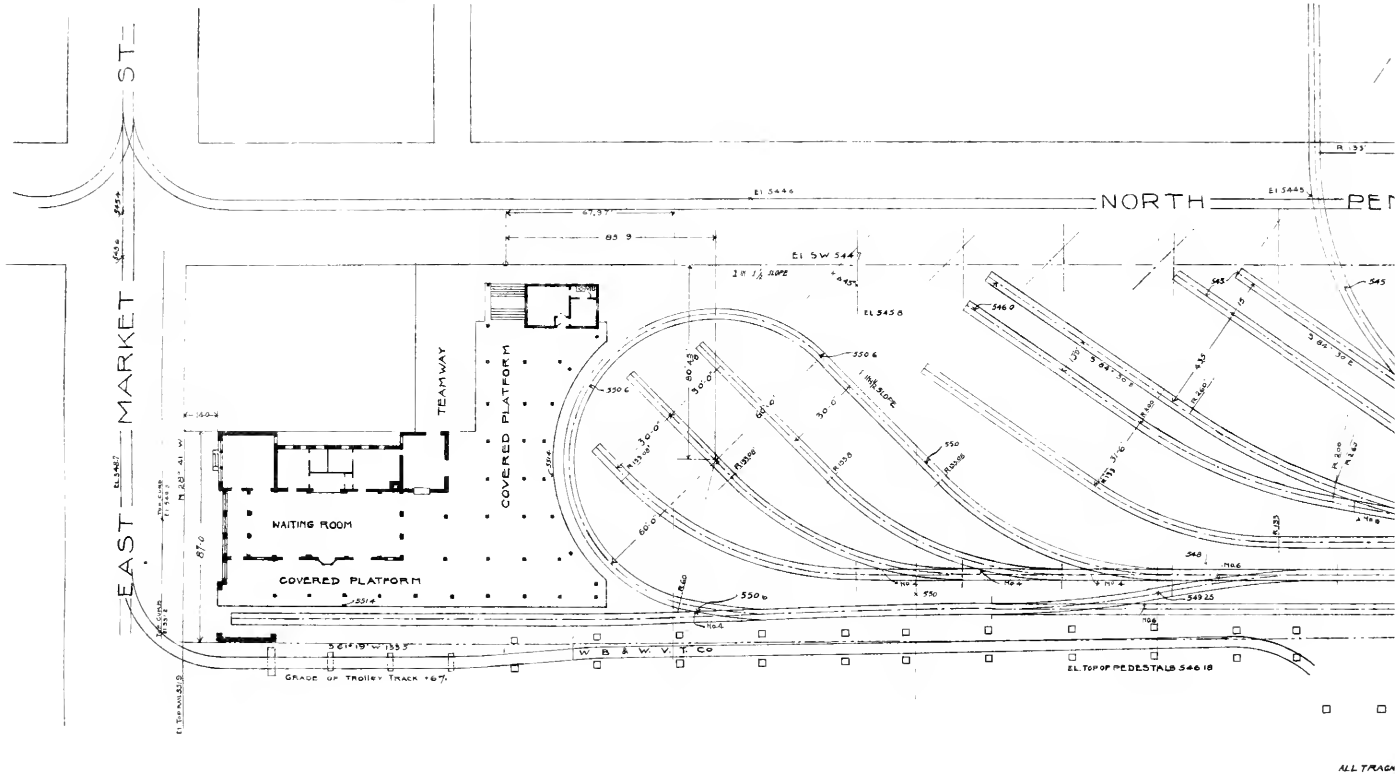

MAP SHOWING THE LINE OF THE
LACKAWANNA & WYOMING VALLEY R.R.
SCALE OF MILES
0 1/4 1/2 3/4 1 2 3
SCALE OF KILOS
0 1 2 3 4 5
WEST WYOMING BOROUGH
EXETER BOROUGH
SWOYERSVILLE BOROUGH
Edwardsville
Luzerne
FORTY FORT BOROUGH
WYOMING BOROUGH
Wyoming
Kingston
Dorranceton
Forty Fort
MARCY TOWNSHIP
Plainsville
Exeter
WEST PITTSTON BOROUGH
West Pittston
Pittston Jc.
Lackawanna
Duryea
Oldforge
Barber town
River
SCRANTON
DORRANCETON BOROUGH
HANCOCK STATION
HILLDALE STATION
INKERMAN STATION
Port Griffith
PITTSTON
WILLIAMS ST. STATION
DUPONT STATION
Minooka
Moosic
WILKESBARRE STATION
RIVER ST. STATION
MIDVALE STATION
JENKINS TOWNSHIP
Hudson
AVOCA BOROUGH
MOOSIC STATION
MOOSIC
LACKAWANNA TOWNSHIP
SCRANTON STATION
DUNMORE STATION
WILKESBARRE
Miners Mills
MINERS MILLS BOROUGH
Parsons
YATES BOROUGH
Smithville
SO. AVOCA STATION
N. AVOCA STATION
ROCKY GLEN STATION
BOROUGH
SO. SCRANTON STATION
NAY AUG STATION
LAFLIN BOROUGH
PLAINS TOWNSHIP
PITTSTON TOWNSHIP
JENKINS TOWNSHIP
Stafford Meadow Brook
ROARING BROOK TOWNSHIP

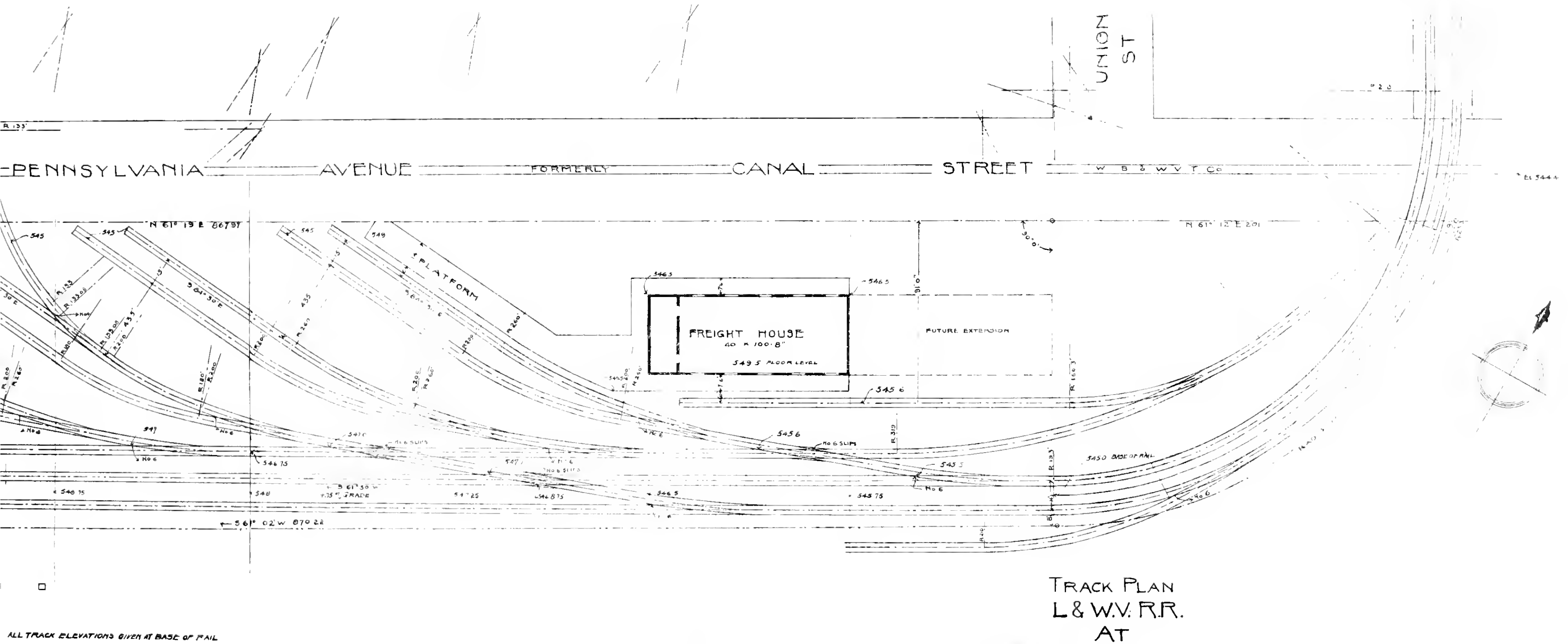


L. & W. V. R. R.—PROFILE OF GRADE FROM WILKES-BARRE TO SCRANTON

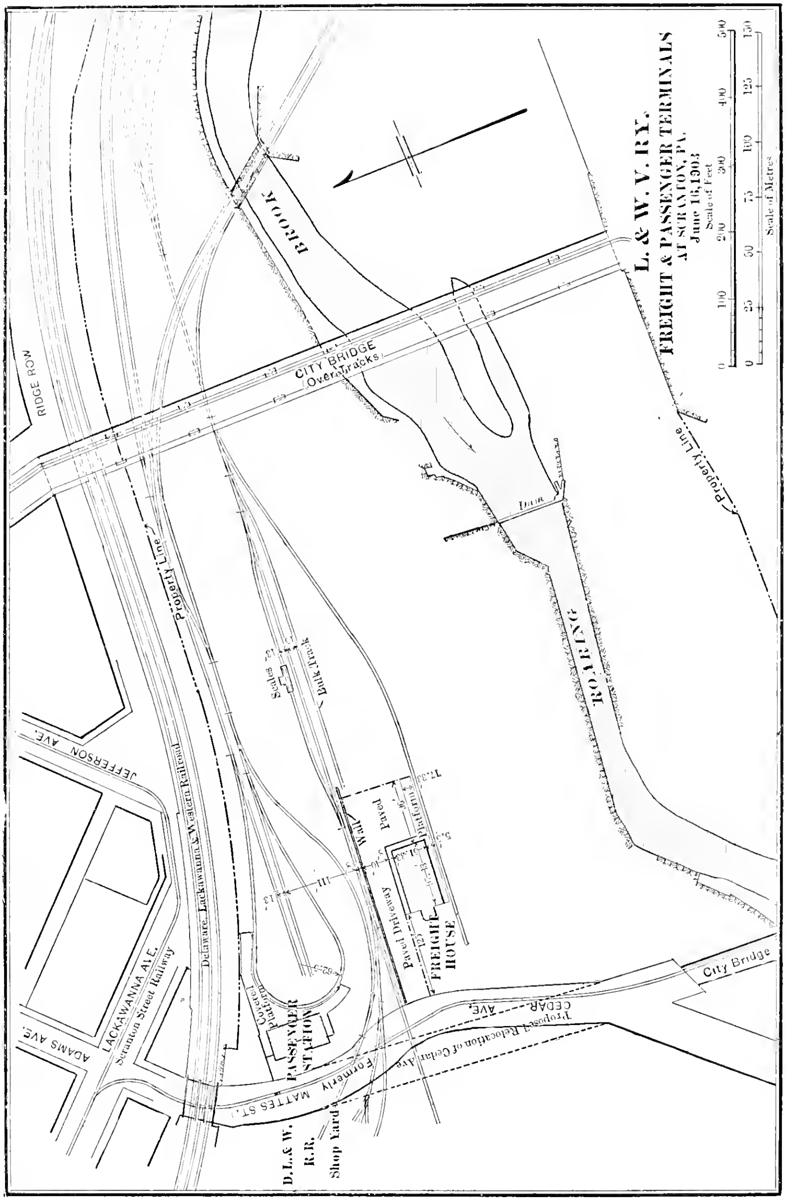
HORIZONTAL SCALE, 1 IN.=8000 FT.
VERTICAL SCALE, 1 IN.=100 FT.

FEB 10, 1904.


EAST MARKET ST
NORTH PEN
TEAMWAY
COVERED PLATFORM
WAITING ROOM
COVERED PLATFORM
W. B. & W. V. T. Co
GRADE OF TROLLEY TRACK +6%
EL. TOP OF PEDESTALS 546 18
ALL TRACK



TRACK PLAN
L & W.V. R.R.
AT
WILKES-BARRE TERMINAL
SCALE 1 INCH = 45 FEET
OCT. 9, 1903.



Freight and Passenger Terminals at Scranton.

The chimney is 118 feet high, 9 feet 10 inches inside diameter, and is of Alphonse Custodis construction. Worthington feed pumps are installed. The steam piping is standard, full-weight wrought-iron pipe, magnesia covered. The Holly gravity return system is used for returning drips to the boilers. The valves are extra heavy, with outside yoke and screw. The engine room is large enough to house three Westinghouse vertical cross-compound type engines, two of which are now placed. The rated capacity of these engines, with 160 pounds of steam pressure, is 2000 horse power, but they can be run at 60 per cent. overload. The generators are A. C. D. C. type, of 1250 k. w. capacity. There is also a duplicate set of exciters, independently driven. The other engine-room appliances, such as switchboards, transformers, condensers, etc., are all of first-class type.

At Hancock, fourteen miles from the main station, is a substation, equipped for reducing the voltage for conversion into direct current. This building is also arranged for a passenger station.

The pole line, from the main power house to the substation, consists of 30 to 35-foot cedar poles, set 5 feet into the ground and 100 feet apart. These poles carry three No. 4 B. & S. hard-drawn copper wires, arranged in a triangular form on umbrella-type glass insulators. The high-tension current is of 22,000 volts.

The third rail weighs 75 pounds per yard, and is unprotected. It is supported on each fifth tie (which is of extra length) and is bonded with two 400,000 C. M. bonds. At gaps there are two 300,000 C. M. cables placed under ground in conduits of creosoted wood filled with pitch.

The track is bonded with two 4/0 protected rail bonds under the angle bars. There are cross bonds of 250,000 C. M. every 500 feet along the track.

In Wilkesbarre there are several grade crossings of streets, and, for a short distance, an overhead trolley is used in place of the third rail, all of the cars being equipped with trolley poles. The contact shoes on the cars are of the gravity pattern and take the current from the top of the third rail.

The road is operated throughout the day on a twenty-minute interval between cars, with extra cars morning and evening, which make a ten-minute interval.

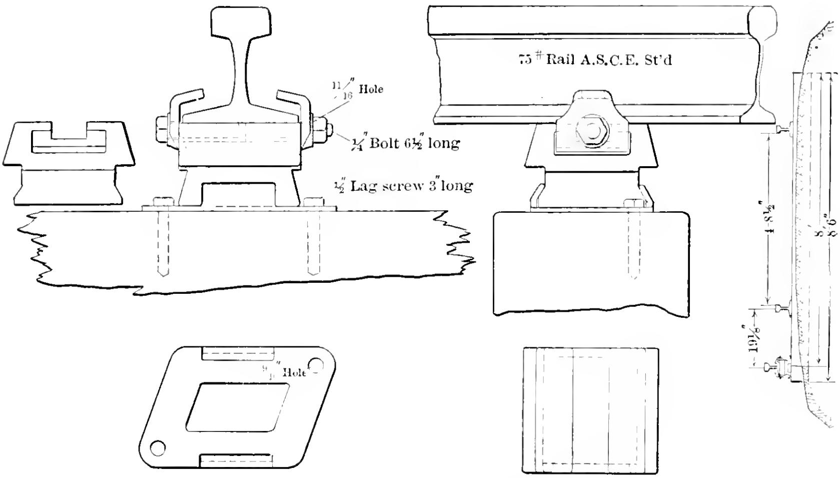
Special cars, on a five-minute or other interval, are run when required. Multiple-equipment trains will be run as required.

The public appreciates the convenience of the road and gives it a liberal patronage. As far as possible, tickets are used, and the

general rate is one and one-half cents per mile. Cash fares are a little higher.

Westinghouse, Church, Kerr & Company, of New York, have acted as Chief Engineers, Auditors and Contractors for the electrical equipment, stations, track work and rolling equipment.

The Security Investment Company, of Pittsburg, Pa., has managed the financial part of the operation. The other principal contractors have been John R. Lee, of Paterson, N. J., for grading, masonry and ballast work; The King Bridge Company, McClintic-Marshall Construction Company and Phœnix Bridge Company, for



Third-rail Insulator, Lackawanna and Wyoming Valley Railroad.
Distance from Top of Running Rail to Top of Third Rail, 3 in.

bridges, and The American Car and Foundry Company, for equipment.

The total cost of the road, as far as constructed, including right of way, terminals, grading, masonry, track, power house, electrical work shops, car house, etc., has been nearly $6,000,000.

Mr. Charles F. Conn has acted as business manager during the construction, and is the Vice-President in charge of operation.

Mr. George F. Huggans has been the Civil Engineer in immediate charge of location, grading, masonry, bridging and track work.

Supervision of the building work and electrical equipment has come from the office of Westinghouse, Church, Kerr & Company, and has been largely executed on the ground by Edward M. Decker.

THE VALUE OF INSPECTION OF METAL BRIDGES DURING CONSTRUCTION AND ERECTION.

By Walter L. Golden, Member of the Engineers' Society of Western New York.

[Read before the Society, May 5, 1903.*]

When a superabundance, or at least a considerable amount, of literature has appeared on any subject in which engineers or those interested in engineering enterprises are concerned, further suggestions are usually offered with some deference or apology; and, while some discussion and not a little criticism has appeared now and then on the question of the value of inspection in our technical publications, an impartial presentation of the facts and conditions of the inspection business will perhaps not be an unwelcome subject to those present, and not without interest to those unacquainted with the practical workings of an inspection bureau.

In our great system of civil government we recognize three departments—legislative, executive and judicial. We intrust the legislative with the work of framing the statutes, rely on the executive to enforce them and on the judicial to solve all questions arising as to their validity. Now, while our faithful legislators may give us an ideal code of laws, the essence of a model government, we still consider enforcement by the executive as absolutely essential, and consequently the judicial; even though the latter may often be found wanting and may be subjected to just or unjust criticism, we would consider it the height of folly to dispense with their services on this account.

Similarly, an intelligent engineer, when he has drawn up his code of rules, or specifications, as we may call them, in accordance with which a bridge or other structure is to be built, may expect to follow the work with his watchful eye, or that of those in his employ, to see that his designs and methods be not accidentally or intentionally disregarded. His envoy of protection is the inspector, who, though often the object of abuse and criticism, deserved or undeserved, cannot be dispensed with any more than can our executives of the law, who may at times come short of their duties. The only hope lies in their betterment by organization and co-operation of the individuals they protect.

One of the exponents of the engineering profession prefixes his specifications with this pertinent clause: "The most perfect

* Manuscript received March 12, 1904.—Secretary, Ass'n of Eng. Socs.

system of rules to insure success must be interpreted upon the broad grounds of professional intelligence and common sense," evidently realizing that there must be considerable latitude between the text and practice of building bridges and other structures; the one is the ideal, the other the practical. But, even with this expectation of a certain difference or leeway between the two, the contractor undertaking the work would hardly be given the liberty of taking an "inch or mile" as he might see fit. Here the inspector has an important duty to perform, for, though the standard of shop work is constantly improving, and in its present methods of system and precision which characterize the modern bridge shop is one of the marvels of modern manufacture, this can hardly be said for the honest performance of that work, and this inspection must regulate.

The inspection of iron and steel structures dates back to the time when the first were constructed, though the service has until a dozen years ago been performed by the engineer, his assistant in charge or some individual employed by him for this service. All the railroads had their own corps of inspectors under the engineering department, and the old iron bridges of earlier days were subject to the most rigid kind of inspection in manufacture, erection and maintenance. Later, certain men of some engineering and practical experience took up this line of work exclusively, and performed the service for the engineer at a fixed rate. As demands for the service of inspection increased, due to the more universal use of steel for structural purposes and the consequent boom in building structures of this class, the services of these inspectors being required in a number of mills and shops located in widely separated districts at the same time, the formation of so-called inspection bureaus became a necessity, in order to economically perform the work. So that one man, instead of traveling about to various districts on work of a varied nature and following each job through consecutive stages of mill, shop and field, and thus wasting much time and money in traveling, located in one district under the employ of the bureau, cared for all their work (secured from various engineers) in that district, be it at shops or mills, and other representatives cared for that portion of the work in other districts. The present custom of ordering material for one job from a number of mills wherever the best price and time limits for delivery can be secured, and likewise subdivision of shop work to different companies or different plants of one company, has made the system of co-operation of inspectors and consequent formation of bureaus a necessity. To-day the most extensive railroads still have their own inspection corps; some, however, prefer to have

this work performed by outside inspectors, in the aggregate amounting to thousands of tons a month—only one factor which makes the inspection business so extensive and keeps a considerable number of these bureaus alive. Added to railroad work is that of highway bridge construction, structural buildings of all classes and machine construction, including all mill and shop equipment and conveying machinery. To illustrate the variety of inspection, here is a catalogue showing the various lines of inspection under the care of one bureau on which they are working at the present time: Bridges (railroad and highway), buildings, ship hulls, boilers, machinery, locomotives, steel and wooden cars, standpipes, riveted water pipes, steel rails and cement; it also maintains a laboratory for chemical and physical tests of building materials. An idea of its extensive practice may be had when it is known that this bureau inspected and tested materials for seventy-five different railroads in the three years, 1898 to 1901, and this only one of half a dozen or more such bureaus; nothing can better show the recognition inspection has commanded in the last few years.

The first regularly organized inspection bureau was that of Hunt & Clapp, Pittsburg Testing Laboratory, in April, 1883, the next following soon afterward, that of G. W. G. Ferris & Company, and, later, R. W. Hunt & Company, Osborn Engineering Company, J. A. Colby and R. W. Hildreth & Company. Of the large bureaus such as these, there are not more than eight concerns, and, added to these, a number of smaller inspecting firms. In the Philadelphia district (the most extensive for rolling and fabrication of structural material), five of the large bureaus are represented and half a dozen of the smaller ones.

An inspecting company, to perform its work effectively and economically, requires a carefully organized corps of inspectors and clerks. A regular detailed system, approved by experience to be capable of operating with regularity and uniformity, is the only safeguard against mistakes, lost records and careless work. It may be of interest to follow through the various stages of inspection in the usual order as practiced by inspectors, and note what care is taken to secure for the engineer and purchaser the structures they have ordered and expect to fulfill certain conditions and specifications. The natural order of work is mill, shop and field inspection, and, while each of these three may be complete before the next is begun, it is more often the case that all three classes on one structure may be going on at the same time, nearly up to the state of completion. The third stage, that of field inspection, in many cases is not performed by the bureau having mill and shop

work, but is either looked after by a regular field inspector hired by the engineer, by the engineer or his assistant or by no one at all, the last being not an unusual occurrence in some classes of work.

First Class: Mill Inspection.—When a contract for a bridge or other structure is let, the engineer notifies the inspecting company and bridge company who are to do the work, the former being supplied with a copy of the engineer's plans and specifications. The plans are examined and forwarded with special notices and memoranda to the inspector located at the contractor's shops. The bridge company orders the material at one or various mills and sends duplicate copies of these orders to the inspection office, which in turn sends one copy of the orders to their inspector at the mills; the estimated weights of the order are then made and kept for reference. Each mill inspector compares the order he has received with the mill's own order, to see that no change or mistakes have been made. As the steel is rolled, test specimens are cut from different sections on each heat, as specified, and the physical test for ultimate strength, elastic limit, elongation, reduction of area, character of fracture, cold and quench-bending tests are made, and such additional tests as the engineer or specifications may require. Record is kept of these tests, and if in conformity to specifications are accepted; if not, rejected, and new tests ordered and made; in case these fail, new material is required. Drillings are also taken from each heat for chemical analysis, and this is performed by the mill chemist and his work turned over to the inspector, who forwards all these records to his home office (retaining his own copy), and the office forwards copies of them to the engineer. As fast as rolled, the inspector is required to examine material for surface defects and flaws, straightening, size, proper handling, etc., noting that the shapes bear the heat numbers for which he has pulled his test. He informs his home office of the material he inspects each day, and as material is shipped he checks the invoices for the same with his mill-order copy and estimated weights.

At the head office the items on the invoices are again checked when received and forwarded to the engineer. Thus the engineer is kept reliably informed as to the condition of material for his work, both as to reliability shown by testing and promptness of manufacture and delivery; he cannot be deceived by excuses or needless delays on the part of the manufacturer. In following out the above order of his work, the inspector, of course, may meet various disagreeable complications; for example, it may be that

when the order for material was placed at the mill no mention was made of inspection or the specifications covering it; this information is often suppressed intentionally to get a cheaper price on material; in this case, the appearance of an inspector at the mill is hardly a pleasure to the mill manufacturer. Much has been written and said of late as to the real value of mill inspection of structural material; some question whether it is really necessary that it should be done at all, but simply accept the manufacturer's guarantee that the material is all right. Boiler plate, armor plate, guns, eye bars, cable and other similar material are inspected and tested with great rigidity and care, are required to come closely within specified limits and are rejected as unsafe if they fail; but can inspection of the enormous amount of structural steel manufactured into our buildings and bridges be ignored or left to the manufacturer? The object of the inspection is to give to the engineer an independent assurance that the material, tested according to specification, is a good, suitable quality for the purpose intended; he also wants the least expensive way of arriving at this assurance. Now, the manufacturer can see no reason why material pulled at fifty thousand pounds per square inch should be rejected as being low in tensile strength when the designer has only used fifteen thousand pounds as a tensile strength for the basis of his calculations; to his mind, it is good enough. The natural result is that this rejected material, though not suitable for one order because of rigid inspection, will be acceptable on another where there is poor inspection or none at all. The engineer specifies that his structure shall be made of material of uniform hardness and strength, not hard in one part and soft in another, or weak in one piece and abnormally strong in another. Not that these conditions, if they do exist, will cause the structure to fall down; but to have it correctly proportioned, and take no chances on any part of it failing, he guards against them.

He may rest assured the contractor, with his own business interest at heart, will hardly co-operate with his views, unless an independent umpire is at hand to protect *his* interest. So much for *testing* material.

As to surface inspection, it is the opinion of many that surface inspection does not pay, as the mills guarantee all their products and agree to replace, immediately and without question, any material thrown out at the shop because of surface defects. To the writer it appears that certain surface inspection *is* necessary and should be insisted upon; material should be inspected for heat numbers, to see that they correspond to those for which the tests

were pulled. As to defects due to imperfect rolling or crop ends resulting from not cutting off a sufficient amount at ends of the pieces, it is far better, if possible, to inspect these at the mill. Suppose the mill *does* agree to replace anything rejected at the shop; they are aware full well that in doing this a certain amount which passes at the shop would not pass at the mill. The reason for this is that in the course of the manufacture of a bridge, in the usual hurry to get the contract out on time, faulty material will in many cases be used as not being seriously defective, or else be supplied from stock carried by the shop. The writer has in mind a defective I beam, a part of a large building under construction at an Eastern shop; there had been a lap in rolling, and any mill inspector would have rejected it as defective. The shop superintendent placed it on supports at either end and, giving it a few blows with a heavy sledge near the middle, where the lap occurred, without any apparent effect, pronounced it satisfactory, and it was used in the structure; this building was a case where inspection was not considered necessary. As to the practicability of surface inspection, it can be secured at the smaller mills; at the larger ones it is a very hard matter. To secure it at these mills it is necessary for purchasers and engineers to demand that the mill shall provide a suitable place for the material where it can be inspected between the process of rolling and loading, if surface inspection is to be thoroughly accomplished.

Much has appeared in the last few years relative to further tests and examinations of steel and iron other than a tensile and bending test, upon which material is accepted at present. Without describing in detail the new methods, mention of only the important ones may be of interest. Messrs. Hunt, Allen & Condron have made tests of material, using a new machine constructed by them, which measures the amount of work done as this machine punches or shears a plate or other test-piece, showing more nearly the strength developed by the material in the actual shop working of it than a simple tensile test. The impact test is also one of recent development, detecting inherent brittleness of materials, and has a large field of usefulness. The method and machine for testing materials for impact was invented by Mr. S. B. Russell, member of the American Society of Civil Engineers, and he presented a paper on the subject before the American Society in 1899. A very important quality recognized by engineers is that of resilience, or resistance of steel to sudden shock. The work done on the test specimen and its resulting change of form is a valuable addition to the physical and testing laboratory. Its practicability for regular

tests on manufactured material is still to be recognized. Mr. F. S. Rice has made some worthy suggestions on the value of microscopic inspection of steel, resulting from examinations he has made of specimens (some of new material and others of old material long in service), and they go to show that from specimens which are carefully polished, when examined with a microscope of no very high magnifying power, much can be learned of their composition and texture. All these methods of testing are worthy of consideration and would make valuable supplementary tests to those now in common use; it may not be long before some of them will be adopted, and recognized as not too expensive to be specified for regular tests of structural material.

Second Class: Shop Inspection.—In the manipulation of material and the many details that are involved in its manufacture into one complete structure, a shop inspector is, of course, a prime necessity. His duties are a category which, when carried out in all its details, keeps him a busy man from the start of the contract to its finish. If true in the mill, it is doubly true in the shop that unless all workmanship during the stage of manufacture in the shop be competently and honestly inspected, much of the purpose of scientific design and specifications is destroyed. To those unacquainted with shop practice or how it is carried on in a multitude of plants, both great and small, the many ways in which work can be intentionally or not intentionally slighted, and the subterfuges used to hide these variations from specified rules, would be somewhat of a surprise; in this day of large output, when each shop is straining every nerve to manufacture material up to or beyond its rated capacity, the superintendent and his foremen, in their eagerness to satisfy their employers, can hardly be expected to watch the engineer's interests; the quickest and cheapest way, with reasonable certainty of holding together, is their business motto. In fact, the shop drawings are about all the men work by, with the notes added thereon from the specifications of certain features which, in the judgment of the shop's engineer or draftsman, are worthy of mention; in half the cases where the superintendent's attention is called to points in the specifications not being followed in the work he is ignorant that such a specification exists. It may be his duty to read them, but is often his privilege, and perhaps duty, to forget. So for these reasons it is not hard for a casual observer, when passing through a shop, to note which contracts are under inspection and which are not. The practice of subletting parts of contracts in certain shops and classes of work requires careful inspection both to keep track of the structure as a

whole and watch its manufacture. Though this practice is often economy or perhaps a necessity to a shop not able to perform the entire contract, competition may cut the price to a figure, at which good work can hardly be done. This is sometimes explained afterward by the subcontractor in the statement that inspection was not figured on when the work was taken.

Some very interesting and practical tests for built-up girders and truss sections were recently made by special arrangement of certain interested engineers with one of the large structural shops; the results showed in the girders tested that 21 per cent. was added to their strength by drilling rivet holes and use of power riveting. Other sections showed even greater superiority of high-standard work over the ordinary. Care was taken in drilling and riveting these sections, of course; but only the same care which would also be taken on work under good inspection. Now, on those structures where the engineer specifies solid drilling, or even reaming of punched holes, it behooves him to have this work watched very carefully, if he considers this added strength necessary to his structure.

Punching full size, up to certain thicknesses of material, is, of course, much cheaper than drilling or reaming, and will be done if possible. The machine riveting will in most cases be done, but there is a good and also a bad way of machine riveting. These tests are only one thing which goes to show in what degree good or poor manufacture may influence the efficiency of the structure.

An investigation into the collapse of a bridge over Tinker's Creek, Bedford, Ohio, back in 1896, was a case of no inspection; added to the fact that the bridge was weak in design, the material was passed with a high percentage of phosphorus, and double punching of holes in tension members was allowed. As a result, the bridge collapsed under a heavy live load.

The routine work for a shop inspector is something like this: As soon as the material begins to arrive at the shop he makes weekly reports on the work to the general office; he receives from the bridge company a full set of drawings for the structure; checks them with the engineer's plans in detail, and also by themselves in detail; he makes a careful estimate of the weights of all parts and a complete marked list of the same; in checking drawings it is often necessary for him to alter field connections to facilitate erection and many other minor details; it is his duty to be about the shop at all times and during progress of his work, and watch the various processes of manufacture from start to finish, that they be in accordance with his specifications; he inspects the condition of ma-

terial before fabrication and identifies it as that rolled for his structure; by watching all stages of manufacture closely he can stop poor work that may be covered up or hidden in the finished material, and can correct errors easily, saving time and expense for the shop, to say nothing of expense and profanity in the field. When finished, he gives the pieces final examination and checks their measurement in detail; special care does he use in checking clearances and field connections, two most important points and at the same time the most difficult to check from a shop inspector's standpoint; the painting inspected and work accepted, he stamps the material *as* such, and, after seeing it weighed correctly and loaded properly, he reports its shipment in detail; he receives copies of the shop invoices for the shipment and checks them carefully, informing the shop and his office of errors in the same. He reports each week on three forms: first, of mill material on hand for fabrication; second, of work in process of manufacture; third, shipments of finished work. At the completion of the contract a detailed final report is prepared, showing actual and scale weights of all material in classified form, and also a complete report of all shipments made and data concerning them, accompanied by a descriptive report of the process of manufacture, noting any unusual features or defects that may have arisen, rejected material, causes for delays in progress of the work and other data for record. All these reports and records are made in shape for filing, the inspection bureau keeping duplicates of them as furnished to the engineer; at any future time, any question arising concerning the structure, reference can be made to them and the information furnished by the bureau, if desired. The inspector is also required to keep a diary record of his work and time spent on each class of work, with expenses chargeable to each, and send each week to his office, where a check can be kept on his movements and disposition of his time. This is the routine work of a first-class bureau's inspector, and this category requires him to be a very busy man; the wide range of his work demands it, and the most important point in good inspection, in fact the thing which distinguishes it from bad inspection, is that of his presence at all times during manufacture; a cursory examination of *finished* work may be *inspection,* but it is not *good* inspection; it is, rather, *assumption,* and much of the value of inspection is lost; we may add that it is lost when cheaper inspection is secured.

All of the larger shops now employ, and have employed for a number of years, a shop inspector of their own; his work includes all jobs passing through the shop, and with a copy of the drawings

in hand he goes over, as far as possible, field connections, as a check on the accuracy of the various workmen, and for this part of the work he is responsible to the shop; *there*, however, his duty ends; unless there is something extremely irregular about the material as finished which may cause trouble in erection, he distinctly understands that in serving the interests of his employer anything further is out of his jurisdiction; and the manufacturer expects that any further correction will be called to his attention by the outside inspector, and not his own.

As to the attitude of the shop toward the first-class inspector, as a rule it depends on the amount of trouble the inspector finds it necessary to make for the shop; errors in manufacture, anything that will prevent the material from fitting properly, the former will gladly listen to and correct; but further than this, as to faulty manipulation, careless finishing and the like, the inspector finds that the manufacturer is not easy of persuasion, and sometimes is both stubborn and aggressive under the force he may be obliged to bring to bear on him. The superintendent regards his own methods as good enough, for he considers cost and output at the same time; and, in the event of any interference, he either tolerates the inspector as a necessary evil or seeks his removal; and, in justice to the inspector and the standing he has obtained in the shops in latter years, it is much harder for the manufacturer to have him removed on any complaint of his own than it was a few years ago. In the majority of such cases the inspector against whom the greatest cry is made is the one who is most thoroughly trying to fulfill his duty.

A few engineers have attempted at times to specify that the manufacturer shall make certain specimens of full-size sections similar to those entering into structures of importance, for the purpose of testing by loads and stresses similar in character for which they are designed; this work has been done in a few instances, but, of course, the manufacturer does not accede very heartily, and it will require the concentrated action of both engineers and inspectors to make these tests in future as customary as they are desirable. It would certainly give all concerned a much better idea of just how much our sections, details and connections are exceeding or falling short of what they are supposed to carry, and at the same time show the standard of *shop work*. These added tests, of course, would only be considered necessary on important classes of structures.

Third Class: Field Inspection.—To any fair-minded engineer, field inspection as a supplement to mill and shop inspection on a

structure is a prime necessity, and it is recognized as such on about all railroad work and usually on all important structures. In many cases the structural engineer has his own field inspector or a corps of field inspectors, though of late years a considerable amount of it has been done by inspection bureaus.

The railroads, unless they are small roads, have their own field inspectors on construction as well as maintenance. The Government usually does its own, also, though in some few cases outside inspection is employed. Any engineer acquainted with the usual methods and workmanship of erection must know that mishandling of the material or faulty work at this stage of the structure may undo many points of design that may have been successfully secured in shop manufacture, and render it not only weaker than it was designed, but weak enough to cause actual failure sooner or later. And yet it is surprisingly the case that on a large class of building work and not a little bridge work good field inspection is considered too expensive a luxury to warrant its employment.

Some architects, engineers and purchasers expect to pay a reasonable price for the inspection of large and necessarily expensive structures, but little or nothing for that of smaller and less expensive structures. Of structures failing and causing loss of life and property, the majority are not of the ultra-expensive class; and, without saying that lack of inspection was the direct cause of failure, in many cases, where no attention is paid to the workmanship on erection of this class of structures, failure can be reasonably expected. Many of the insurance companies are looking carefully into the conditions under which a structure has been inspected during manufacture and erection before issuing a policy on the property.

As to the duties of the field inspector, though not so numerous or varied in character as that of his comrade in the shop, in performing his daily routine of work he usually finds plenty to keep him busy if the work is proceeding with reasonable rapidity. He keeps a record of all material delivered at the bridge site and sees that it is unloaded and transported properly from the cars to its place in the structure, examining it, at the same time, for injury received in transportation and errors in shipping invoices of each carload; it is necessary for him to be thoroughly acquainted with both the original design and shop details of the bridge, if the structure is of any complicated nature whatever; in fact, he must understand it so well in all its connections and details as to know where

each separate piece is designed to fit; these details the foreman, and even the superintendent of erection, in nine cases out of ten, knows little about, and as a usual thing both rely on the inspector for this information. To the uninitiated it is surprising, in structural work, how a little misplaced material, which at first sight may seem to fit in place, is found, a little later, to belong elsewhere, the consequent change perhaps entailing much trouble and expense; the *shop marks* on all of these pieces usually govern the erector, and he unfortunately pins his faith on a not very certain guide; especially is this true in work that has been wholly or practically all assembled and the field connections reamed in the shop; to obtain the best results and benefit derived from this method of insuring good field holes, the parts must necessarily be assembled the same way in the field; and, without inspection, this will in most cases not be done. The inspector examines the quality of all workmanship on the bridge, and any attempt to slight or injure the work he prevents before it proceeds further; he is the engineer's daily representative on the job, and reports to him all matters and questions that arise in its prosecution; also, all difficulties and delays of an irregular nature, and these he incorporates in a report to the engineer weekly or oftener, as circumstances may require. It is evident, to carefully and thoroughly carry out this regimen of inspection, faithful and constant watchfulness is the engineer's only hope for a perfect job. No mere cursory examination at irregular or even regular intervals, such as is the all too common practice on some classes of work, will secure it for him; not only does it apply to steel work, but also all other materials entering into important parts of the structure, especially those subject to loads.

The collapse of a building under construction in New York in September of 1896 is only one example of the fact that building operations in every city need to be very carefully watched, in the interest of public safety, to prevent careless and willfully bad work being done. This was by no means the first accident of this character for New York City. The city building department was blamed, but a lack of appropriation for building inspection was the real cause of the disaster. There was, in 1896, in New York City, $90,000,000 expended for new structures, and in the same year $177,000, or one-fifth of 1 per cent., for inspection. From $\frac{1}{2}$ to 1 per cent. should have been allowed for this class of work. Granting every city building department to be honestly and efficiently managed, and every one of its inspectors to be absolutely honest and faithful, it is still certain that, with the limited appropriations which are generally allotted to city building departments, their

inspection must be too hasty and incomplete to insure discovery of every defective building, even though they may usually succeed in doing so. The time may come when this will be remedied—when ampler means will be furnished to building departments for their work—but it should be fully understood that under existing circumstances the inspection made by the city should never take the place of or relax the vigilance of the inspection that should be carried on on behalf of the engineer or architect and the owner. In *this* class of inspection a great opportunity for improvement exists. The best architects, conducting a large and well-systematized business, have an efficient corps of inspectors; but on the great bulk of building inspection carried out under the direction of ordinary architects, or in many cases without the aid of any architect, inspection is often a very crude attempt. That this should not be goes without saying. The owner of a building is responsible for its safety and can be held for damages if it fails, due to faulty construction; his insurance policy is also void in case of failure of the building; therefore, if he neglects to provide inspection to secure its safe construction he runs a heavy risk. Besides, an expenditure for inspection will mean, in many cases, a more durable structure—one that will involve less expense for repairs for many years; his attempt at saving by disregard of inspection is in reality a waste. There is an opportunity for the establishment of inspection bureaus for this class of work (that of building inspection) similar to those for structural bridge work. At present, the purchaser of a building has no adequate assurance that the structure is securely built. Such purchaser would pay somewhat more for a structure, if with the deed he received a certificate of an inspection bureau of wide reputation that the structure had been continuously inspected during its construction and received its approval. And when purchasers asked for or demanded such certificates, the builders who erect to sell, or owners building for investment, would find it to their advantage to employ such a bureau. Moreover, such a bureau can perform the work of inspection more efficiently and economically than the ordinary architect. He could have special men for machinery, lighting apparatus and other details of the work with which the average architect or his assistant are often not familiar. Thus, many architects would prefer to place the inspection in the hands of a bureau rather than undertake it themselves. This solution of the building problem is dependent, in a great measure, on the *purchaser's own demand* for safe inspection.

Following the field inspection of work under construction on

bridges and other important structures is that of *maintenance inspection* and provisions for its prosecution.

Special means for obtaining easy access to the superstructure of large bridges in order to perform the necessary work of inspecting, repairs and painting, is a matter which deserves greater recognition than it has generally received from engineers. European bridge builders have paid some attention to such features in a few instances, an example of which is the great steel-arch bridge at Muengsten, Germany, where an elaborate system of traveling staging for reaching all parts of the metal work were designed and built by the engineers as a part of the bridge; but in America there is not one similar structure where such devices have formed a part of the original work. This fact is all the more noticeable because of the number of really large bridges in this country where suitably designed inspection staging or platforms could have been constructed at a very small cost compared with the saving effected by them in future inspection and repairs. No engineer needs to be told that it does not matter how well a bridge may have been designed and constructed in the beginning, it has to be inspected and repairs made frequently thereafter; also, periodically painted, under inspection, as long as it is in service. In nine cases out of ten, moreover, it depends upon the *ease* with which access can be obtained to the metal work which needs these attentions whether care is given it at once, when it will result in the greatest benefit, or whether it is deferred until the conditions are such that the work *cannot* be deferred any longer. One of the most creditable features of the Muengsten bridge cited as an example above (a double-track bridge over 1500 feet long) is that every member of the whole superstructure, including its great arch span of 550 feet in the center, can be easily reached by engineers or inspectors who may for any reason desire to examine it.

The price of field inspection, though often based on the tonnage of the work, as mill and shop inspection is done, is in many cases let to an outside inspection bureau on a day basis. This, in many cases where progress of work is slow, is the only profitable way by which it can be done.

The writer had hoped to be able to describe at some length the condition of inspection work and recognition that inspection receives in the countries across the water as compared with our own, but, unfortunately, was unable to secure any complete data in the limited time available. England, however, has regular inspection bureaus, similar in operation to our own, and structural iron and steel are carefully inspected in rolling and manufacture.

In Germany, the entire work, including inspection, is vested in and performed by the engineer in charge and his assistants, and the system of inspection bureaus is almost entirely absent.

In conclusion, it may be of interest to note a few of the reasons usually advanced by engineers or purchasers why inspection is not necessary:

First. Reliance placed on the honesty of a good bridge company. To be sure of satisfactory results, with no check on the quality of the work turned out, and to look upon such a check as reflecting on the honesty of the bridge company, is a view that is hardly consistent in matters less important. We look upon a man who buys a watch as a *fool* if he pays for an Elgin and gets a Waterbury because he did not examine it before purchasing; yet when a purchaser accepts and pays for a bridge he accepts blindly his new possession with only the verbal guarantee of the bridge company. It is not a question of the integrity of the company or its management; but through all the hands that the tons of material must pass on its way to completion, each individual leaves the results of his work, either good or bad, and each man will look to his own interest first; everyone in the concern's employ, from the laborers to the manager, recognizes that "business is business." The purchaser would cease to be scrupulous on this point if he kept this trite saying in mind when tempted to trust to the tender mercies of the manufacturer; on the other hand, the bridge company that has nothing to fear from the inspector will welcome him to the shop to see that the work is done in the best possible manner and up to the standard of the structures for manufacture.

Second. That the work in hand is hardly of enough importance to warrant inspection. In this day of economic construction, when the parts of a structure are designed so accurately for their intended loads, the allowable working stresses and resulting sections are figured proportionately the same on one class of work, whether it be for light or heavy load; even granting that lower factors of safety be used on secondary work, they are used not because it is considered that less care will be necessary in manufacture of material, but because in supporting the lighter loads the uncertainty of sudden heavy loads and impact which may be developed in a structure of greater magnitude are in a great degree lessened; and, as was pointed out before, it is in this great middle class of structures that failures mostly occur.

Third. That the work will be seriously delayed by inspection, owing to the time required for the duties of the inspector. As a matter of fact, material that is being manipulated rightly, with

good workmanship in every way, is not delayed in the least by the checking and examination the inspector gives it. Complaints of delay are often made by a shop against an inspector, but as a rule it is due primarily to faulty workmanship, which the inspector has not allowed to pass without correction; these delays are naturally aggravating to the shop, especially when a time limit is set on the completion of the work, but the fault is not with the inspector; delays are not to *his* liking; as the price for inspection is paid by the ton, the quicker the job is completed the greater will be his profit.

Fourth. That the work of inspection is not effective because often carelessly done, and the price paid for it is thrown away. Unfortunately, this has been but too true in the past: inspectors did their work carelessly, many mistakes were overlooked and inspection was in many cases more of a farce than a benefit; and to-day many jobs of inspection are taken and performed in a similar way, for they are taken at a figure so absurdly low that the inspector can afford to give them only the most meager attention; the work is handled so as not to lose money on a contract, regardless of the employer's interests. Tales of carloads of material that have been shipped and never seen by the inspector are not very convincing as to the value of inspection, but an engineer should be just as careful in the choice of his inspectors as he is to see that his work is inspected. There are a few bureaus which are striving for the improvement of inspection service by means of establishing a careful system for the thorough handling of the work and employment of only reliable men; and such bureaus *can*, and *do*, give the quality of work that renders inspection valuable. Their greatest difficulty is to secure the work, in competition with the smaller inspectors, who agree to take the same work at a ridiculously low price, without any idea of doing it properly; and here architects and engineers are to blame when they do not distinguish between qualities of inspection, and too often let the work to the firm that will do it at the lowest figure, regardless of their facilities or reputation; these are the engineers and architects who cry so loudly at the inefficiency of inspection. The old rule that "what a man pays for, that he will get," is quite universal in its application, and is no exception when it comes to inspection. If good inspection is desired, then good inspection must be paid for, and it is only good inspection that is valuable.

Fifth. That the price of inspection is too high. As to the price at which good inspection can be done, the following may be said: About six years ago one of the most experienced bridge

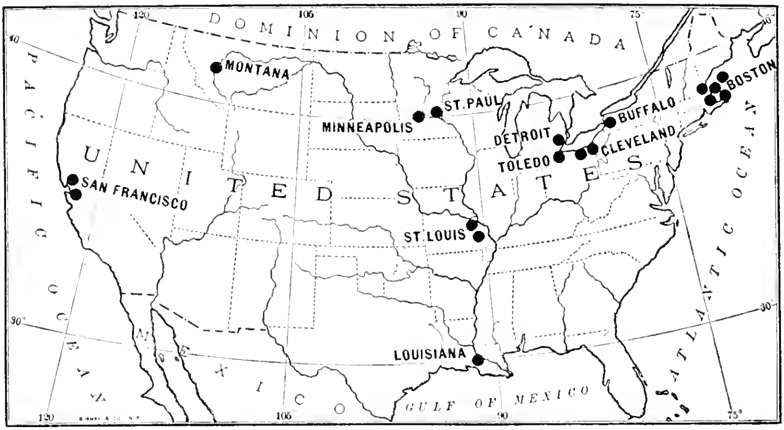
engineers of this country, Mr. J. A. L. Waddell, submitted to several inspection bureaus a set of instructions to inspectors at mills and shops in which was incorporated his own idea of what thorough inspection should consist, with a request for bids on the inspection of a large order of structural steel under these rules and with his specifications. The bids received varied from $1 to $1.25 per ton of 2000 pounds, and Mr. Waddell found, in subsequent experience, that the inspection he called for was worth $1 per ton for large orders and slightly more for smaller ones, where greater expense in proportion to the output of the shop was entailed; however, it is very seldom that such a price is paid in this country for inspection. One acquainted with this particular set of bridge specifications knows it is one of the most thoroughly rigid sets of specifications under which bridge work is done, and of all of the prices at which inspection in mill and shop is taken, varying from 35 cents to $1 per ton, whether taken under specifications as rigid as these or less, the quality of the work performed will be according to the price paid.

At times, and under specially favorable conditions as regards the location of a bureau's employees, it can be done for less than $1 a ton. On small jobs it may be more, but there is, in general, a chance for the inspector to make a fair living at that average price. In consideration of what engineers and architects receive for their services, is from 1½ to 2 per cent. too high a price to pay for inspection of a structure in shop, mill and field? Is it too high a rate of premium to pay for security? The question, Does inspection pay? then is answered: whether you want *good* inspection at a cheap price or are satisfied with *poor* inspection at a cheap price, the latter is what you will get. On the other hand, if you are willing to pay a *reasonable* price you *can* get good inspection, and only good inspection pays. The most experienced architects and engineers already realize that only first-class inspection is valuable. They are taking pains to see that only first-class men are employed at a fair price. Inspection bureaus who enjoy the patronage of such men are doing all their work the best they know how, and are fondly hoping for the dawn of the day when the general public will recognize the value of the efficient service so rendered.

Much of the success or failure of inspection depends on the individual ability and character of the inspector. Good inspectors are not easy to find, and, when found, they are worth more than the cheap bureaus can afford to pay them. A successful inspector must have a rare combination of good qualities. He must be a

practical man, with long training in mills and shops. He must thoroughly understand all the details of the various processes employed and what are the various faults that are liable to result from each process. He must so well understand these faults as to be able to detect them at once, and he must be so well informed as to know how best to correct them in the most practical manner, and when correction is not possible. But experience in mill and shop practice alone will not suffice; he must also understand enough of structural engineering to recognize the relative advantages of different details and designs; he must be able to figure out the strength of the various connections and parts, and have accurate judgment to determine just what effect a loose rivet here or a bad fit there may have in the resulting structure; he must, withal, be a good deal of a diplomat. The inspector who cannot deal with each mill and shop foreman in the way to best command his respect and secure his co-operation will never make a success.

The inspector's life is not all sunshine; he has many a disagreeable duty, and, unless he has the necessary judgment and diplomacy, there will be much friction between him and the men in charge of the mills and shops where his work is located. But a good, sensible man, with the qualities of a good inspector, will gain his points without engendering bad feeling; will get over the rough places tactfully, and do his work quietly and unostentatiously, but effectively. Some day the public will appreciate how important his work is, and then the inspector and the inspection business will receive the respect it deserves.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

Editors reprinting articles from this journal are requested to credit not only the JOURNAL, but also the Society before which such articles were read.

ASSOCIATION
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ENGINEERING SOCIETIES.

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ARGENTINE: PAST, PRESENT, FUTURE.

BY ELMER L. CORTHELL, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before that Society, December 17, 1902, and before the Detroit Engineering Society, April 3, 1903.*]

IN 1899 the Argentine Government, having conceived an extensive project of river and harbor improvement, and made the preliminary surveys, requested the United States Government to recommend an engineer who would come to Argentine and assist the Government by his advice in forming and executing the plans.

I had the honor of being selected for this position. After carrying out a two years' contract with that Government, I have returned to my own country with some knowledge of the conditions and some experience in meeting them. These form the basis of this lecture.

At the final general session of the International Navigation Congress at Düsseldorf, July 4th, this last year, when called upon to respond for the Argentine Republic, I used the following words:

"It may not be out of place to make a few comparisons between the two countries which, by a singular coincidence, I have the honor to represent—one as a delegate to this Congress; the other as a member of the Permanent International Commission. One of these countries is the Argentine Republic and the other the United States of North America.

"Both are cosmopolitan; both have been populated largely from Europe; both had the task of supplanting savagery by civilization. The red races in each case had to give way to the Caucasian, or be assimilated with it. Both have great plains and im-

* Manuscript received March 14, 1904.—Secretary, Ass'n of Eng. Socs.

mense river systems. The greatest river valley of the one is almost exactly equal to that of the other. Similar causes have produced nearly similar hydraulic conditions in each case. Both countries have temperate climates; both, great mountain ranges; both, some extent of arid lands and running waters for irrigation; both, immense areas of rich soils, made so by similar beneficent causes; both have extensive pasture lands and millions of cattle, sheep and horses. In their cereals they are competitors with each other in the food markets of Europe—one is great and ambitious, the other smaller but earnestly devoted to progress and ambitious to fulfill its high destiny among the nations of the earth."

By comparisons of the unknown with the known we appreciate and learn, and for that reason I shall compare Argentine with the United States in respect to some of its more important features, and you will see that the two great countries have much in common.

You must, if possible, imagine yourselves in a situation exactly opposite from yours in the United States in regard to the sun and the poles of the earth; you must look north for warm winds and south for cold ones. Your winter will begin in June and your summer in December. The north side of your house will be sunny and the south side in the shade. As you travel north from Buenos Aires, the capital, it will grow warmer; as you go south you will at last reach the glaciers. Your north star will be changed to the Southern Cross, and in all these changes you will at first be lost. You must also locate yourself geographically, and recollect that the northern line of Argentine is in about the same latitude south of the equator as Havana is north of it, and that the southern limit of Argentine corresponds to Labrador and Kamchatka, and that Buenos Aires, Capetown and Melbourne are all in about the same latitude; also, that there are east and west differences. Buenos Aires is in about the same longitude as Cape Breton Island, east of Nova Scotia, and the circle of longitude along the most westerly boundary of Argentine nearly passes through Boston; and the course from the entrance of the River Plata to Liverpool is nearly a straight line. In order that the location of Argentine in reference to other South American countries may be appreciated, it should be stated that Buenos Aires is as far south of, say, Caracas, the present center of revolutionary and unstable South America, as the north end of Lake Winnipeg, in Manitoba, is north of Caracas, or as far as the northern part of Greenland is north of New Orleans.

With this orientation of ourselves on the western hemisphere, and with these remarkable differences in position, let me call your

attention to a very remarkable similarity wherein will be seen and appreciated the beneficent work of the Great Creator long before at least the present race of mankind inhabited the two continents.

In a paper read before the American Association for the Advancement of Science, at Buffalo, August 5, 1896, upon the delta of the Mississippi, I described the ancient conditions of that great river in substance as follows:

First, a deep shore line of the Gulf of Mexico, when the site of Galveston was far out in the waters and the coast was 100 miles inland from the site of New Orelans—a wide and deep estuary 1000 miles long, reaching into the heart of the continent to between St. Louis and Cairo, where, at Cape Giradeau, it met the ridge of the Ozark Mountains, stretching across the valley and holding back the ancient great lake, which covered Chicago 200 feet deep and spread over all the great prairie States and received and distributed over its bed the immense sediments of the Missouri and other great rivers in the North. Then came the cyclic change, lifting Florida out of the water and turning continental drainage north, cutting its way through the alluvion to Hudson Bay. Then the breaking down of the Ozark barrier; the draining of the submerged area; the subsequent filling of the estuary and the advance of the alluvial lands into the gulf to their present line, 110 miles beyond New Orleans. A great and wonderful beneficence for the use and convenience of man by the Great Architect of the Universe.

Had not my engineering experience upon the Mississippi River and its delta drawn my attention to this extremely interesting ancient history of the great river of North America, I might not have been so deeply impressed by its remarkable similarity with that of the Paraná River in South America; and for both histories I am indebted to engineering investigators—General Warren, in the first instance, and Colonel George Earl Church, an American engineer living in London, in the second instance, the latter probably better acquainted by personal contact with the geography and hydraulics of South America than any other living man.

I am indebted to him and the Royal Geographical Society, of which he is a director and correspondent, for most of what follows in relation to this *ancient* history of the great rivers of Argentine and Central South America.

There are four great breaks in the mountain-fringed continent which we call its great commercial doorways: the Orinoco, the Amazon, the La Plata and the deep indentation of Bahia Blanca—one in Venezuela, one in Brazil and two in Argentine. The three river basins occupy two-thirds of the entire area of South America.

The two with which we are most interested in this lecture are the La Plata and Amazon, which have areas, respectively, of about 1,200,000 and 2,722,000 square miles. But if we deduct from the latter the valley of the Tocantins, which has no direct connection with it, the valley of the Amazon is 2,368,000 square miles; its principal branch, the Madeira, has a volume of discharge nearly equal to the Amazon itself, and at the falls, which I shall refer to later, it carries annually a volume equal to that of the La Plata, which has a minimum flow of about 534,000 cubic feet per second and a maximum of over 2,000,000—a river 80 per cent. larger than the Mississippi, "the Father of Waters," if we compare their mean annual discharges, the former being about 288 cubic miles and the latter 156 cubic miles. The Paraná ("the mother of the sea" in Indian language), the principal affluent of the La Plata, is itself 46 per cent. larger than the Mississippi, its mean annual discharge being about 230 cubic miles.

What a river the La Plata must have been in ancient times, when it had a maximum discharge of 4,000,000 cubic feet per second, well up toward the modern Amazon, estimated to be 5,297,000, and greater than the ancient Amazon!

I have described the ancient conditions of the Mississippi—the Gulf of Mexico as a great estuary and a deep shore line extending well into the heart of the North American Continent. The same conditions existed in the contour line of South America in the La Plata estuary. It extended 1400 miles into the Continent, and was 400 miles wide—eleven times greater than the Empire State. It was the great "Pampean Sea," receiving the drainage not only of the present Paraná and its tributaries, but of the great Madeira River, with its immense discharge of waters and sedimentary matters—the source of great alluvial formations, discharging into a sea two-thirds the size of the Mediterranean.

When, in the processes of nature, the great underwater plains of rich soil had been formed during the comparatively short period of less than 100,000 years, a dam was thrown across the Madeira by the Rivers Grande and the Parapití coming down from the Andes, and a deposit more than 170 feet deep occurred, forming this dam, which produced the ancient Lake Mojos, with an area of about 115,000 square miles, larger than that of the Great Lakes of North America combined, which is less than 94,000 square miles.

During this process the ancient lake and the Pampean Sea were connected, and their relation was similar to that of the Black Sea and the Mediterranean. Traces of it are still observable, notably the great, low, flooded morass of Xarayas, on the upper

Paraguay River, and the ancient delta of the Paraná, including the Ybará lagoon. The Salina Grande was also an arm of it—a great inland fiord. The sea, moreover, must have covered large areas of Paraguay, Corrientes, Entre Rios and Uruguay, and, before the uplifting of the country, it extended southwest to the rivers Chadi-Leofu and the Colorado, lapping around the southern slope of the Ventana range, until the curved rim, concave to the northeast, which connects this with the Sierra de Cordova, was sufficiently elevated to completely cut off its southwestern extension.

This range was high enough to lodge the glacial rocks coming from the Andes, one of which at Tandil is so poised and delicately balanced that the hand can rock it, but it cannot be dislodged. This range later prevented the entrance of the destructive sea, protecting the great area from its waves.

Then came another factor into the beneficent problem of the Creator. Instead of draining the waters from the great deposits under the Pampean Sea, as He did in North America, He lifted the Andes higher, and with them their Atlantic slopes, until the latter were ultimately lifted to their present level, forming the "plains of the pampas," the soil of which is 50 feet deep and of surpassing richness—an area of 600,000 square miles, one-fifth the size of the United States and five times that of Great Britain. Thus by cyclic changes in the northern hemisphere, and by fluvial and sedimentary action and seismic changes in the southern hemisphere, have been formed the great interior agricultural regions of the United States and Argentina.

In order to give an idea of the size of the Paraná River, it may be stated that its annual flow is double that of the Ganges, three times that of the St. Lawrence, four times that of the Danube and five times that of the Nile. We have records of *608 cubic miles* in one year.

There are differing conditions of importance between the Paraná and the Mississippi, explaining the causes of the greater discharge of the Paraná. While they both flow south, one flows from colder to warmer and the other from warmer to colder regions; and it is in the warmer regions in both cases that the rainfall is the greater. On the Mississippi, in the northern regions, where we find the greatest drainage area, the rainfall is about 35 inches per annum; in the southern, where the area is less, the rainfall is 60 inches per annum. With the Paraná there is a rainfall of about 60 inches in the northern part, where the drainage area is greater, and about 40 inches in the southern part, where it is less.

The length of the Paraná River is about 3000 miles; its naviga-

ble length, between Cuyabá in the north and the mouth of the Paraná in the delta of the La Plata, is 1825 miles. The Uruguay River, from San Javier to the delta of the La Plata, has a navigable length of 603 miles. The Paraná River is made up of the two important rivers which unite at the city of Corrientes—the Paraguay and the Alto Paraná. The length of the latter above Corrientes, to the falls of the Yguazú, is 365 miles, and it is navigable nearly to that point. These wondrous falls excel in beauty, as well as exceed in dimensions, the Niagara Falls.

The latter are 160 feet high, as a maximum, and $\frac{4}{5}$ of a mile long, including Goat Island. The Yguazú are 213 feet high in one leap and 106 feet in two leaps, and $2\frac{1}{3}$ miles long, with, at times, an immense volume of water.

The view before you is from a painting by a well-known Bern painter, Mr. Methfessel, who was engaged to come to Argentine, visit the falls and make a large painting for the La Plata Museum.

The gorgeous and varicolored foliage of the luxuriant subtropical vegetation, which abounds on all sides, adds a charm to the falls. They rank among the most beautiful and wonderful works of the Creator.

The Uruguay is an entirely different river, in every respect, from the Paraná. It is, at times, a mighty river, rivaling the Paraná; at others it sinks into comparative insignificance. The Paraná is a great river at all times.

The Paraná is a type of a truly great river; the Uruguay represents a mighty torrent of extraordinary dimensions.

The Uruguay rises near the Atlantic seaboard in Brazil, in the Sierra del Mar, then runs west to the highland of the Territory of Misiones. These highlands prevent it from uniting with the Alto Paraná River at that point, which is only about 68 miles distant. Along 600 miles of its course from San Javier to Concordia the bed of the river is filled with rocky ridges, which, at low water, prevent continuous navigation, but during the floods, which are quite sudden but not long continued, the river is everywhere navigable. The river rises, in floods, at Concordia about 46 feet. Compared with the Paraná, it is a clear stream, carrying very little sediment in suspension. The Paraná is an entirely different river. Its source being in the tropical and rainy region of Brazil, on the flanks of the Andes, its floods are much longer continued. At the confluence of the Paraná and the Alto Paraná at Corrientes, the rise of the floods is about 33 feet; at Rosario, 225 miles above Buenos Aires, it is from 19.7 to 23 feet or $23\frac{1}{2}$ feet in extreme floods. When these occur, the river is about 23 miles wide, cover-

ing the entire country with a depth of 6 to 10 feet, and extending to the highlands of the Province of Entre Rios.

The physical characteristics of the bed of the river are, consequently, entirely different from those of the Uruguay; the bed of the latter is stable, that of the former very unstable. The sedimentary matters carried in suspension, however, are very much less than those of the Mississippi; probably only one-tenth of the amount carried in the Mississippi in times of flood. For this reason the changes in the bed and banks are less radical; the most noticeable change is the movement of the islands and bars down stream. For example, the island of Espinillo, in front of the city of Rosario, lying in the middle of the river and about 2½ miles long, has moved, flanking, down stream about 2½ miles in the last 50 years, and by this movement the advancing bar of the island has approached the river bank in front of Rosario and closed up the navigation channel.

The maximum velocity in great floods often reaches 6½ feet per second, although usually it is much less, equal to that of the lower Mississippi.

Both rivers are susceptible of improvement by dredging, the one to Asunción, which is 842 miles above the mouth, and the second to Concordia, which is 230 miles above its mouth. In the Paraná there is nothing but sand to be removed throughout its entire length; in the Uruguay there are several places where it is necessary to remove rock and gravel. But, generally, the channel can be deepened by hydraulic, or suction, dredging.

The National Government is under obligation, by the law passed by Congress for building the port of Rosario, to make and maintain a depth of 21 feet at low water in the Paraná River from the head of the delta to Rosario, and in the delta of the La Plata to Buenos Aires a depth of 19 feet at low water, which is about 21 feet at mean high tide. It has been proposed to make and maintain a channel of the following dimensions: From the mouth of the two rivers, at the island of Martin Garcia, at the head of the La Plata estuary, to Rosario, a depth of 21 feet and a width of 328 feet; Rosario to Santa Fé, 292 miles above Martin Garcia, 19 feet deep and 328 feet wide; Santa Fé to Corrientes, 10 feet deep, and the same depth to Asunción. Santa Fé, or its seaport Colastiné, is the head of ocean navigation; above that point it is river navigation by steamboats.

On the Uruguay River it is proposed to make a channel 19 feet deep and 328 feet wide, from Martin Garcia to Conception del Uruguay, 137 miles above Martin Garcia, and thence 15 feet deep

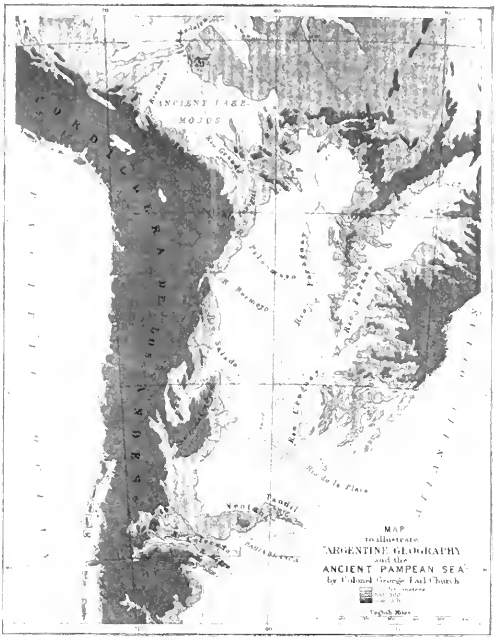
to Colon, and 9 feet deep and 8 feet over the rock to Concordia, which is 230 miles above Martin Garcia.

The low-water plane, or zero, in both rivers is that of extraordinary low water, so that, generally, the low water does not reach this plane within about half a meter to one meter. Consequently, there can generally be depended upon from 2 to 3 feet more water than I have stated. Between Rosario and Buenos Aires there are now no bars over which there is not 21 feet of water at zero, although two of them need to be dredged and buoyed in order to make a straighter channel. This the Government is prepared to do.

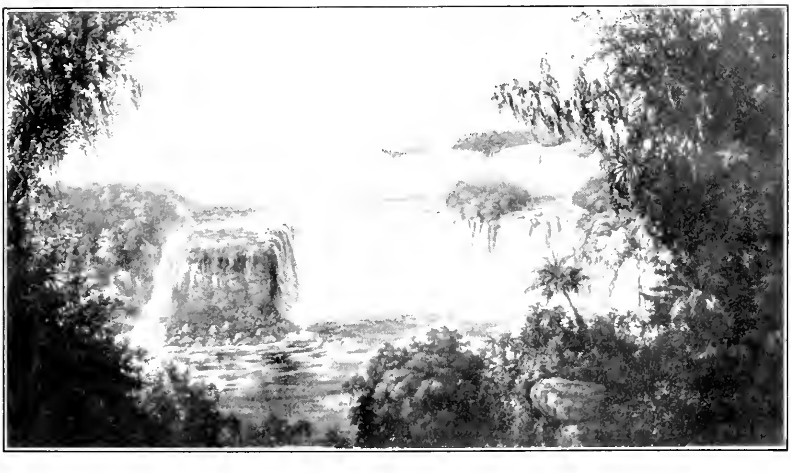
As to the port of Rosario, a contract has recently been made, under the law of Congress, to make a modern seaport at this point, with all the latest and best facilities for handling cargo. The commerce of Rosario is at present 1,500,000 freight tons per annum. It is a very important exporting point for cereals, and when the port is completed according to the plans adopted, it is expected to be an important importing port as well. There are ports below Rosario, such as Villa Constitución, San Nicolas and San Pedro, and above Rosario, Diamante, Santa Fé, Colastiné and Paraná. On the Uruguay River, Concordia, at the head of steamboat navigation, is an important importing and exporting port for that section of the country. Its registered tonnage is about 500,000 tons, and the actual weight tonnage about 100,000 tons.

The country between the Paraná and Uruguay Rivers is practically isolated from the rest of the country, and its situation is very similar to the country lying between the Euphrates and the Tigris; for that reason it has been called the "*Mesopotamia Argentina.*"

There are at present in this area three railroad systems—the Argentine Northeastern, which runs from Corrientes, on the Paraná, to Monte Caseros, on the Uruguay, and from there to Santo Tomé, on the same river; the Argentine Eastern, from Monte Caseros to Concordia, and the Entre Rios Railroads, the main line of which connects Paraná and Conception del Uruguay, with branches to Victoria, Gualeguay, Gualeguaychú and Villaguay. Within a few months a connecting line will be completed to Concordia, forming a link between the Argentine Eastern and the Entre Rios systems. It has been proposed to unite these three systems and to extend the Argentine Northeastern from Santo Tomé to Posadas, on the Alto Paraná, passing through the colonies which the Government is establishing in that Territory. Posadas is its capital. The Central Paraguay Railroad, which runs in a southeasterly direction from Asunción, it is proposed to extend to Villa

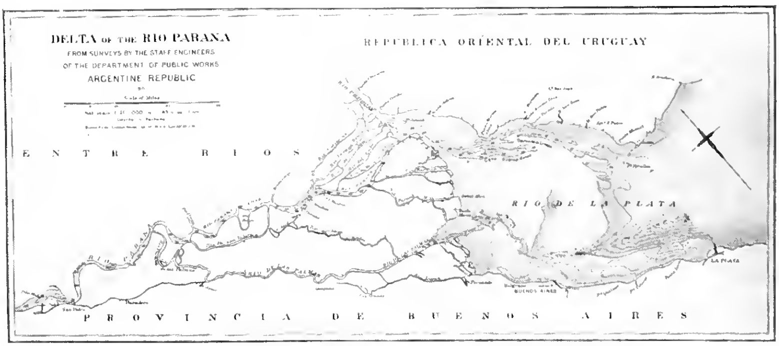


ANCIENT PAMPEAN SEA AND LAKE MOJOS.



FALLS OF Y-GUAZÚ.

Paraná River from Grain Elevator at Rosario.



La Plata Superior and Delta of Paraná

Encarnación, a small town on the opposite side of the river from Posadas; to change the gauge, which is $5\frac{1}{2}$ feet, to the normal gauge of the other three railroads, which is 4 feet $8\frac{1}{2}$ inches; make a transfer by car float at Posadas; extend the Entre Rios Railroads to a port of deep water, either on the Paraná or Uruguay, and do a "through" business between Asunción and this new seaport, which will be only a few hours distant from Buenos Aires.

With the Paraná River improved to Asunción and the Uruguay improved to Concordia; with the railway systems united and extended to a good seaport, this great interior district of the country will have an ideal system of transportation, and the shipper may take his choice, to ship by rail or by water, thus establishing a very useful and reasonable competition between water and railway, to the great advantage of the people.

In reference to the Rio de la Plata itself, it is an immense shoal estuary. It is the depositing ground of the great Paraná River. This estuary, in a not very remote period, extended above Santa Fé; this is shown by the comparison of old maps, of which 92 have been collected and copied and placed in the library of the Ministry of Public Works. These maps date from the year 1529 to 1885. Even in this comparatively short period, remarkable changes are shown in the delta of the Paraná, which is now a true delta, almost exactly in the form of the Greek letter Δ. It is 40 miles across its face; it slowly extends itself in the head of the estuary, and through the delta nearly a dozen outlets of the Paraná River find their way. It is very much like the deltas of the Danube, Ganges and Mississippi.

The superficial extension of the Rio de la Plata exceeds 18,000 square miles; it is about 186 miles long, and varies in width from 186 miles at the ocean, between Capes San Antonio and Santa Maria, to 1.12 miles at the extreme point of the head of the estuary, at Punta Gorda.

To understand the physical conditions of the estuary, it is necessary to divide the Rio de la Plata into superior and inferior, or upper and lower. The Rio de la Plata superior lies above a line extending between La Plata and Colonia, the inferior below that line to the sea. Over a distance of about 25 to 30 miles between Martin Garcia and the anchorage of Buenos Aires there is a normal depth through the best channels of from 16 to 20 feet at low water.

The National Government has recently completed the dredging over the San Pedro bar lying in this region, increasing the depth of $18\frac{1}{2}$ feet to 21 feet, where there was formerly only 15 feet. In the Canal de las Limetas, or Nuevo Canal, by natural forces and

by the constant movement of steamers, there has been obtained a depth of about 19½ feet, or 21½ feet at mean high tide. Opposite Farallon, a rocky point on the Uruguay shore and opposite Buenos Aires, there is, along the course of navigation, about 19½ feet at low water. The Government has buoyed with luminous buoys the entire route from Buenos Aires to the mouths of the Paraná River, the Bravo and the Guazú, and has placed a floating semaphore below Martin Garcia for the benefit of navigation, recording constantly by signals by day and by night the depth of water in the channel. It is now proposing to connect this semaphore by a telephone cable with the telegraph cable of Martin Garcia, so that communication may be established between the ships lying at anchor (waiting for the tide, or passing near the semaphore) and the offices of the agents at Buenos Aires or Montevideo.

A careful study of the different conditions in the delta of the La Plata shows that the only method of improvement in such a vast expanse of water is by dredging and buoying the best channels.

In the lower Rio de la Plata there are very serious conditions. A bar on which there is a least depth of 20 feet at low tide lies between the anchorage of Buenos Aires and Montevideo; the material in this bar is very soft and vessels plough their way through it on ordinary tides, but the great extent of the bar is the serious condition. Between the 24-foot curves, straight through this bar, there is a distance of 24 sea miles. To make a channel by dredging would require the removal of probably 10,500,000 to 13,000,000 cubic yards; and it is very doubtful if, on such broad extension of water and in such soft material, a channel could be maintained. But it is hoped that the plan now proposed of anchoring five lightships in the line of navigation, and in the direction of the current, and which can be seen from each other, will have an effect upon the bar by the continued movement of deep steamers through it. The examination of the Rio de la Plata inferior has been intrusted by the Government to the Ministry of Marine, which is making very extensive surveys and examinations over the entire area.

The estuary at this point is 46 miles wide, and five high towers on shore and others anchored within the area to be surveyed are necessary in order to cover this great Punto Indio bank.

These are the general physical conditions of the Rio de la Plata and its great tributaries.

In addition to the great drainage basin of the La Plata, there are further south, the large rivers, Rio Negro and Colorado, which, combined, have a drainage area of 464,000 square miles. The

channels are not susceptible of improvement for a large commerce, but they will in the future furnish water for an extensive irrigation and steamboat navigation.

The hydraulic conditions are great, but the mountains are greater, and have exerted a powerful influence on the continent, not only upon its climate and its running waters, but upon mankind. On these lofty table-lands lived the Incas and flourished their great empires. Among the clouds have fought for supremacy the Incas' troops and the Spanish soldiers, and here, too, have the struggles for liberty taken place; here Bolivar and San Martin led their troops to victory and continental freedom from the domination of Spain.

An orthographic map of South America will show what immense areas are given up to mountain ranges and lofty summits. In their widest part the Andes are 500 miles in breadth. Some mighty force seems to have pushed them and the entire continental line eastward and massed the ranges into a complex system of mountains, towering isolated peaks and parallel, transverse and interlaced ridges without number. In Bolivia, not far north of the country we are describing, there are thirty-two peaks above 17,000 feet high, some of them reaching over 21,000 feet; and in Argentine is the lofty Aconcagua, lifting its solitary crown to an elevation of 23,080 feet, rivaling the loftiest mountains of the world. And Famatina, in the Argentine Province of Rioja, rises to 20,680 feet, and the grand mountain Tupungato 22,015 feet high.

Between Argentine and Chili, between latitude 23 and 35 degrees, the mountain passes, which are from 10,000 to 14,000 feet high, are blocked with snow from May to August, and they are swept by violent storms.

The height of the passes, all the way from 7 to 37 degrees south latitude, Northern Peru to Southern Argentine, shows the determination of nature to oppose transit by man, piling up in his pathway these almost insurmountable obstacles. When it is considered that this immense barrier covers a sixth part of the circumference of the globe, its influence upon the development of the Continent is apparent.

It is unnecessary to go into the history of the South American Republics. Their origin and development are easily found in any good American library. But it may not be generally known that, from the first arrival of the Spanish adventurers to the successful end of the great struggle for liberty in South America, there was always dissatisfaction, unrest and hatred of the conquering race. The seeds were sown in bloodshed, in the persecution by the In-

quisition and in false commercial and governing methods of Spain and Portugal, the mother countries. The difference between North and South America in this respect was very great.

It is a significant and curious fact in the history of South America that, during the entire eighteenth century, the same causes were producing the same effects among people far separated from each other and of a character entirely distinct, scattered from the banks of the Paraguay River to the Colombian Mountains.

Those effects may have been the precursors of that great revolutionary movement that created our great Republic and drove the Bourbons from the throne of France, and, later, shook to the center the monarchical fabric of Spain herself.

We may, therefore, say that the struggle and the preparation of the ground for civil and religious liberty began earlier in South America than in North America. In the British Colonies there was no strong sentiment against foreign rule until the imposition of the taxes required to furnish George the Third with revenue to pay off his debt of 148,000,000 pounds sterling. Even Washington, in July, 1775, when he took command of the Continental army, declared that the idea of independence was repugnant to him. Only later, and soon, when the war was suddenly upon the Colonies, did events hasten and make inevitable the separation from the mother country.

It would be a subject of great interest to enter upon—the three great leaders and heroes of American revolutions—

WASHINGTON—BOLIVAR—SAN MARTIN,

a triumvirate of liberators.

Of the two former you already know much, possibly of the latter, but you may not know that it was by his patriotism and generalship that the whole of Southern South America was freed from the yoke of Spain—Argentine, Chili, Peru and Bolivia. His biography is a romance of most absorbing interest.

Born in 1778, in Argentine, in Japeyú, he received his early education in Buenos Aires; completed it in Spain; served with distinction and great bravery in the wars of Spain. Early he was imbued with the doctrine of liberty for his native country; spent a year in Great Britain in 1811, forming associations and a secret league devoted to the liberation of Argentine. Landed in Buenos Aires in 1812; soon in command of a regiment of Grenadiers; selected soldier by soldier, officer by officer; imposed the most rigid discipline, so forming a rudimentary school for a generation of heroes that followed him, and producing nineteen generals and nearly all the great

Orographic Map of South America.

Statue of General San Martin.

View in the Cordilleras.

Plaza Victoria and Statue of General Belgrano.

men of the struggle for independence. Placed in command of the army to reorganize it, he marched to Mendoza, the nearest point to the Andes, and, imbued with the idea that no liberty would be secure for his country until the Spanish armies were beaten and expelled from Chili, Peru, Bolivia and the whole of South America, he formed his plans for an invasion of Chili. He was the very incarnation of determined patriotism; nothing, not even revolutions and discord behind him in his own country, could deter him from his great work. At this moment Napoleon fell, and Spain prepared an expedition of 15 000 men destined for the Rio de la Plata. In Chili and Peru the Royalists were victorious; but in Argentine on the 9th day of July, 1816, at Tucuman, the declaration of independence was proclaimed, which, like our own, is sacred in the heart of every Argentine.

In the midst of these great and momentous events, San Martin recruited and drilled and clothed and provisioned his little army destined to conquer a continent, to scale high mountain passes and pour down upon an enemy largely outnumbering his own. He ostensibly made roads over certain passes and, when all was ready, led his army over another and very different pass and came down upon his foe and defeated him in Chacabuco; and again on the plains of Maipú routing the enemy completely and assuring the independence of Chili. Then, though anarchy was reigning in Argentine and his Government was calling upon him to return, his fixed and irresistible purpose of dealing the final blow to Spanish authority in Peru pushed him forward. With a fleet hastily gotten together and commanded by Lord Cochrane, and with English and United States officers in command of the ships, he sailed from Valparaiso with his troops up the coast in December, 1818. He had only 4430 men, Argentines and Chilians. The Viceroy of Peru had 23,000 soldiers awaiting this little army. On July 28, 1821, as a result of his campaign, the independence of Peru was proclaimed in Lima, and San Martin made dictator. In the meantime, General Bolivar, after liberating Venezuela and Colombia, reached Quito, and his forces, united with an Argentine division, routed the Spanish army in the battle of Pichincha; and then he hastened on to Guayaquil, anxious to finish by himself the Peruvian campaign. Here let me quote a paragraph from the history of Argentine by the Hon. Martin Garcia Mérou, the Argentine Minister at Washington.

"There he went to find San Martin, whose purity of character and noble unselfishness formed a marked contrast with the impetuous ambitions of his glorious rival. The two liberators had

a conference July 26, 1822, the details of which were kept secret; but it is a well-known fact that San Martin comprehended that, in order to accomplish South American independence and avoid the scandal to the world of a break with Bolivar, caused by the latter's thirst for glory, it would be best for him to depart from a scene where his great presence had no place."

The story of self-abnegation and the rest of his life is told in a word. He resigned the dictatorship of Peru; passed to Chili, to Mendoza, to Buenos Aires, to Europe, where he resided four years in Brussels on a very modest pension. Once more, in 1829, he returned to the La Plata, stopping at Montevideo; but, learning that anarchy prevailed in his own country and deaf to the entreaties of his friends to come to their help, he took a steamer back to Europe, saying, "No, General San Martin will never spill the blood of his fellow-citizens; he will draw the sword only against the enemies of America." And, without even seeing Buenos Aires, he sailed for the last time to his voluntary exile, dying suddenly August 19, 1850. He was free from those theatrical qualities which appeal to the multitude. In this great character predominated those moral qualities which entitle San Martin to a prominent place in South American history. Inflexible in the discharge of duty, a rigid disciplinarian, everything was subordinated to the high mission to which he had devoted himself, and he never sacrificed his cause to ambitious or personal vainglory. *He was the incarnation of an idea.* His modesty, his pure and elevated character, the simplicity of his life and the nobility of his principles give him rightfully a position by the side of the great heroes of history.

In the vicissitudes of the epoch under consideration, when European wars and the disasters of nations reflected themselves directly and indirectly upon the people of the River Plate and led slowly to the formation of the Republics of Uruguay, Argentine and Paraguay, many notable and great men, as well as despots and bloody tyrants and political demagogues, appeared upon the scene and the pages of history. No name more illustrious, contemporaneous with San Martin, is seen in the records of that time; more brilliant and more important in results than that of General Belgrano. His generalship, diplomacy, statesmanship and exalted patriotism give him a most distinguished position in the annals of independence; as General Mitre has well said in the opening sentence of his "History of Belgrano," "this book is at the same time the biography of a man and the history of an epoch." His statue is before us as we stand in the archway of the National Govern-

ment Building and look out upon the beautiful Plaza Victoria. General Belgrano was really the author of the national flag. The white and the blue are the colors of the Patricios, the regiment of native Americans, at the time of the overthrow of the Spanish Viceroy, on the 25th of May, 1810.

Coming to later times, new and illustrious names appear—men who were true patriots, who would not stoop to fraud or unbecoming political act, and who, amid the errors of their time and the temptations to do evil, came out pure as gold tried in the fire. One of these men is the author of the "History of Belgrano"—General Mitre, still living,—the general who led the forces of Buenos Aires in the last struggle for a united republic, and who may be called the Father of his Country; for under his wise governorship, his skillful generalship and wisdom as President, Senator and a public man always before the people, the country has been strong, united, prosperous and peaceful.

The sincerity of his motives, the purity of his life, public and private, his self-abnegation, his rigid honesty, his lofty ideas of public office, administering it always as a public trust, his modest and simple life, all explains why the entire nation recently honored his 80th birthday, and why the statesmen of the Republic sit at his feet to learn and to follow his wise counsel.

I have refrained from developing the political history of the Republic or giving its earlier history—the discovery of the River Plate by de Solis, in 1515, giving the name of his second officer, Martin Garcia, to the now well-known island at the head of the estuary; or the discovery, in 1526, of the Paraná River, by Sebastian Cabot, and all the subsequent and checkered history of the Spanish Portuguese rule in the River Plate countries. That they have passed through many trying periods, when the patriotism of the leaders has been severely tested, goes without saying. The heterogeneous elements, the ambitions of designing men, the lack of integrity in the early days of independence and the opportunities which selfish men had easily in their hands to enrich and raise themselves in political station, gave varied and not always envious political changes to decades of Argentine history, not necessary to inflict upon you now. Suffice it to say that the country has passed safely through those terrible ordeals. The principles of the 9th of July, 1816, in the Proclamation of Independence, and those laid down May 25, 1853, in the Constitution of the United Provinces, form the basis of the Republic—fourteen Provinces (States) and ten Gobernaciones (Territories)—principles which all hold sacred and which are almost exactly similar to our own.

The world, and especially its republics, owe more to Buenos Aires than is generally known or recognized. The brief but eloquent summary of this period of its history by General Mitre shows how great has been its influence in the development of American national life.

I stated, in my remarks at Düsseldorf, that the country was ambitious and determined to fulfill its destiny among the nations of the earth. I cannot close the political subject of my lecture without confirming this statement by the words found at the close of Mr. Mérou's "History of Argentine," which he brings down to 1870.

"The Argentine Republic came out of this campaign (1870, with the dictator and tyrant of Paraguay) strengthened and united. The sentiment of nationality, crystallized by common sacrifices, was from that time forth an indestructible fact and a promise of days of prosperity and greatness, of a country united, free and powerful. We can contemplate the problems of the future with tranquillity, consecrating ourselves with all of our intelligence and forces to build up with a broad and generous spirit and a disinterested love for truth and justice (following the traditions received from our forefathers and realizing their noble ideals) one of the greatest, most prosperous and most illustrious nations of the earth."

It is pertinent here to remark that the principle enunciated in 1818, five years before the message of President Monroe, proclaiming the "Monroe Doctrine" with such quiet but firm determination, viz., that *America* is and shall be the undisturbed home of *Americans*, has persisted until the present day, and if attempts have been made at any time to impair the sovereignty of any American nation, there has always been a Grant or a Cleveland to frustrate them. President Roosevelt has recently clearly defined this much-misunderstood principle, or so-called "Monroe Doctrine," when he said: "The nations now existing on the Western Continent must be left to work out their destinies among themselves," and "America, North and South, is no longer to be regarded as the colonizing ground of any European power." Thus it has happened that while the Dark Continent has been partitioned among these powers, no hand as yet has been laid upon any part of America.

Let us now take a bird's-eye view of the present Argentine, a country one-third the size of the United States; a climate salubrious and comfortable; of immense plains formed by nature, as I have already shown, for the use of man—plains where the railroads find no natural obstacles worth mentioning in the way of

their good alignment and construction; where we have, I think, the longest railroad tangent in the world (186 miles), between Junin and La Cautiva, on the Pacific Railroad; plains covered with the cattle of the great estancias, thousands of them of the best breeds in one estancia, and sheep by the millions, and great fields of wheat, corn and linseed, the principal agricultural products of the country. An "estancia" might be called a "ranch" on the great plains of our Western States. Their size varies from about 3000 acres to 700,000 acres; probably 25,000 acres might be considered an average size.

As might be expected of a country stretching through so many degrees of latitude and rising along the circles of longitude from the level of the sea to the highest Andes, there is a great variety of climate and generally an abundant rainfall. Buenos Aires is on the same parallel south of the equator as Wilmington, N. C., is north of it. Snow is almost unknown, and scarcely ever is ice or frost seen. The climate in the summer is tempered with the great body of water of the River Plate.

The rainfall of Buenos Aires averages 35½ inches per annum, about equal to that of the Northern States of the United States. At Asunción, Paraguay, it is 53 inches, about equal to that of New Orleans. The temperature is remarkably uniform. The mean temperature in June and July, 1899, the coldest months, was 54 degrees F., and in January and February, the hottest, 76 degrees, the annual mean being 62 degrees. In twenty years the mean was 63 degrees; summer, 77 degrees; autumn, 65 degrees; winter, 54 degrees, and spring, 63 degrees; mean of January, the warmest month, 79 degrees; of July, the coldest, 52 degrees. The extreme, or extraordinary, limits were 107 degrees, and very rare 104 degrees, frequently 95 degrees, and in winter 23 degrees, which occurred but three or four times. In February 1900, the heat rose to 103 degrees, but the period of intense heat was only eight days. Such conditions are extremely rare.

The population of the whole country is now about 5,000,000. The wheat area of the Republic, mostly in four Provinces,—Buenos Aires, Santa Fé, Cordoba and Entre Rios,—is about 8,500,000 acres; 80,000,000 to 100,000,000 bushels of wheat are exported. The total area under cultivation in the Republic in 1901 was 17,500,000 acres. The increase over 1891 was 136 per cent. The crops were: Wheat, 1,964,000 tons; linseed, 490,000 tons; corn, 2,134,000 tons. The total of arable land is 253,000,000 acres, of which 240,000,000 do *not* need irrigation.

In the whole Republic there are 30,000,000 head of cattle,

5,600,000 horses and 120,000,000 sheep (in the United States there are 62,000,000).

As might be expected, the wool industry is very important, about 500,000 bales shipped to Europe being the export product in the years 1901-02—31,000 to the United States and 28,000 to Great Britain.

Argentine is a protectionist country, and its resources for conducting the Government are largely raised from the custom dues. In 1899 the imports free of duty amounted to $14,769,933 (gold), and those subject to duty, $102,080,738 (gold). The exports were $184,917,531 (gold). The United States imports $300,000,000 per annum of sugar, hides, linseed, jute, hemp, wood and fruit, and $36,000,000 of wool and woolen articles. All of these are produced by Argentine, yet only $6,000,000 of the $336,000,000 come from Argentine, or 2 per cent.

The United States export, including cereals, meat and live stock, about $920,000,000, and only $10,000,000 of this go to Argentine, or about 1 per cent., while Argentine's purchases of the same articles in England were $39,000,000, and $60,000,000 from other countries.

Reciprocal trade would open the United States to Argentine wool and treble the production in a few years. There should be direct lines to that country from the United States, and the time should be reduced from about twenty-seven days to fifteen or eighteen days. We should ship to Argentine our manufactures, our coal, pine wood, petroleum, etc., and we should receive from Argentine its wool, hides, grease, dried fruits, hard wood for tanning and dyeing, etc. Now, for want of return freights, steamers load at United States ports for Buenos Aires, and return via Liverpool to New York, frequently via South Africa.

In reference to wool, I have already stated that in the entire United States there are only about 62,000,000 sheep, while there are 120,000,000 in Argentine. It is a well-known fact that the ranges in the far West of the United States, which are absolutely necessary for sheep raising, are rapidly being reduced by the extension of our population westward and the cutting up of great areas into smaller farms. Not only do the smaller farmers, as they go West, wage constant war with the sheep herders, but the cattle raisers do the same; so that the time is sure to come very soon when we will need the wool of Argentine. What this country should do with a great agricultural country like Argentine, capable of immense productions, is to receive its raw materials and ship to it our manufactured goods.

It is proper, in closing this part of the subject, to quote a short paragraph which appears in the "Argentine Year Book," recently published, from the pen of Mr. Ronaldo Tidblom, Chief of the National Department of Agriculture and Live-Stock Industry. In closing up a long and very important article in that year book on the agriculture of Argentine, he makes the following statement:

"Nature has undoubtedly endowed Argentina with advantages for agricultural and pastoral farming not to be found in any other country of the world, and it is not too bold a forecast to say that if the country continues to improve her natural gifts in the same degree in which they have been cared for and improved up to the present time, the day will come when the Argentine farmers will have absolute control of the world's food markets."

Railways have had an extensive development. In 1867 there were 355 miles; in 1880 there were 1563; in 1890, 5862; in 1900, 10,601, of which 1243 belong to the Government and 9358 to foreign companies. In length of line, Argentine stands ninth on the list of countries, but as compared with the United States the mileage is about 5 per cent. The paid-up capital is $550,000,000 (gold). The total receipts in 1900 were $40,000,000 (gold). Comparing the railroads of Argentine with those of the rest of the world, we find that Argentine, in mileage, stands ninth. The length of line per 1000 inhabitants is 3.46 kilometers, while it is 4.86 in the United States, 0.93 in Germany and 1.7 in France.

The Great Southern, the Western and some other lines are still making extensions, and the Southern has crossed the Neuquen River and is looking for a pass to cross the Andes.

There are three gauges—5 feet, which is really the standard; 4 feet 8½ inches, and a narrow gauge, usually about 3 feet 3 inches (1 meter).

The total length of telegraph lines is 28,000 miles, of which 12,000 belong to the Government. Compared with the United States, the Western Union alone has 192,705 miles of poles and cable.

One of the most interesting railroad lines now in construction is the Transandine, which, upon leaving Mendoza, follows the Mendoza River to its source and climbs to the summit of the Pass of the Andes, 3900 meters (13,000 feet) above sea level. The Abt system of adhesion up to 2½ per cent. and then rack to 6 per cent. are employed.

Speaking generally of the railroads, they are well constructed, though good ballast on the great plains is lacking. The cars are like American cars, but the first-class day coaches are much more

luxurious than ours. All the long-distance trains have comfortable sleepers; a buffet and dining car goes with all through trains.

In regard to the industries of the country, while the main products are agricultural and the export as well, important industries are slowly developing. While sugar is an agricultural product, the forty sugar mills may be classed among the industries. In 1870 Argentine imported 22,000 tons, but in 1899 exported 58,000 tons. There are $52,000,000 invested.

The history of the city of Buenos Aires is exceedingly interesting and full of trouble. Founded in 1535, destroyed and rebuilt; and then, from 1650, when there were 400 houses, it grew slowly under the old Spanish régime; and later, under dictators and bad rulers, it slowly advanced in spite of an unstable Government. In 1852, when the noted Rosas was turned out, it had 76,000 inhabitants; in 1864, 140,000; in 1869, 178,000; in 1887, 400,000, and there are at present about 880,000. It is destined to reach the million mark by the year 1906. It is now the largest city in the world, south of Philadelphia, if we except Chinese cities.

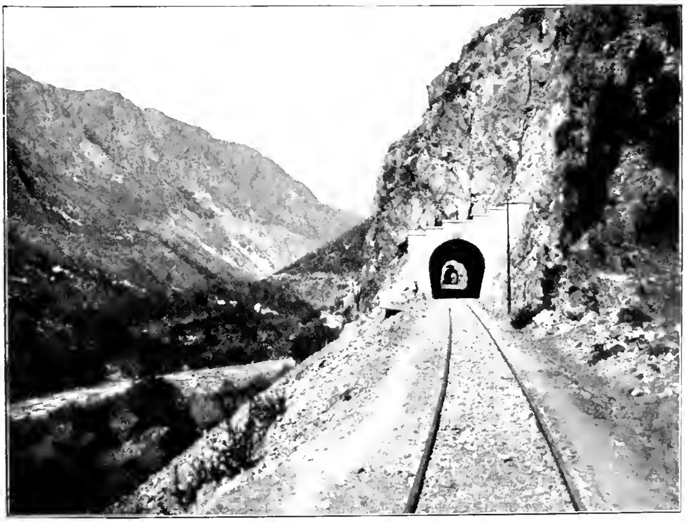
Comparing its present rate of growth per decade with some other cities, we find the following: Greater London, 20 per cent.; New York, 37 per cent.; Chicago, 54 per cent.; Philadelphia, 23 per cent.; Greater Berlin, 19 per cent.; Buenos Aires, 40 per cent.

The city is on the right bank of the River Plata, a sloping bank, 50 or 60 feet above the water level, rising up to considerably greater elevations in the center of the city. It is about 120 miles from the sea at Montevideo. Its area is one of the greatest in the world—44,830 acres. Paris has only 19,280; Berlin, 15,625; Hamburg, 15,681, and Vienna, 13,690. It would be a good day's journey to go around the city, as its perimeter measures 39 miles.

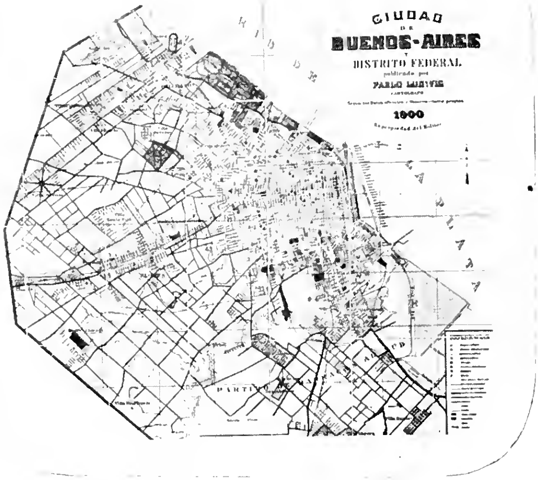
As far as the natural conditions permit, the streets are laid out in the form of a chessboard, and are generally about 360 feet apart from center to center. In the central part of the city the streets are narrow; it is difficult for three carriages to pass. There are, however, a few 33 feet wide, and one or two avenues about 100 feet.

The finest and said to be the best-lighted street in the world is the Avenida de Mayo, which is in the center of the city as to the numbering of the houses north and south. It has a fine asphalt pavement and double electric lights in the center. It was cut through the blocks a few years ago from the Casa de Gobierno (Government House), near the port, to the thirteenth street, somewhat less than a mile. At the other end there is being built a beautiful capitol building that will cost about $5,000,000 (gold).

Flock of Sheep.



First Tunnel Out of Mendoza.

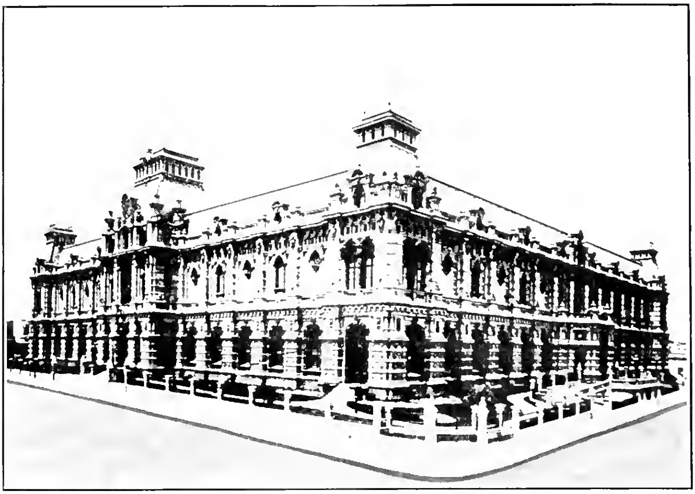


City of Buenos Aires.

Palacio del Congreso.

Plaza Libertad.

Avenida Alvear



Distributing Reservoir.

Cathedral.

There are seventy-two parks and small areas outside the main streets, with a combined area of about 1400 acres. These parks are more tastefully laid out and more neatly kept than can be found in any other country in the world, Paris excepted. In fact, in many respects the city, in its streets, lights, parks and structures, resembles Paris, except that there are more one-story residences than in Paris. The prevailing style is Spanish, with a patio (an open area) and the rooms all facing it, and in this patio a garden and fountain, when the proprietor is able to have it; if not, pots of flowers very much like the ordinary city house in Mexico. The style of the houses of the wealthy may be seen on Avenida Alvea.

The pavements are wood (nearly all hard, suitable wood of the country), asphalt, granite blocks, macadam and rubble. No city has better pavements in the central part. In the outskirts, however, much of the pavement is very bad and uneven, merely rubble, but immense sums are being expended in substituting for rubble granite blocks and asphalt.

There is no city anywhere with more lines of street cars; in fact, with the exception of two streets, there is a line in everyone of the principal thoroughfares. And leading out to the pleasant suburban towns, Belgrano, Palermo and Florest, there are electric lines similar to those in American cities, using the overhead trolley. In fact, all the equipment, from rails to trolley, comes from the United States. Very extensive changes are being made in all parts of the city, substituting horse cars for electric. There are now 275 miles of street-car lines, which carried, in 1900, 116,447,982 passengers.

In 1871 there was a terrible epidemic of yellow fever, due, in a large part, to unsanitary conditions; but immediately afterward the city began a very extensive system of water and drainage works, costing $33,000,000 (gold), discharging the sewage 15 miles distant, and the storm waters, by great intercepting sewers now being completed, into the river in front of the city. The city waterworks take their water above the city, where it is never contaminated. These works were designed by Messrs. Bateman and Parsons, engineers, of London, and the main construction was carried out under their supervision.

The water of the River Plata is good, but muddy, and it is clarified in settling basins before being delivered to the distributing reservoir, built on one of the highest points of the city. This distributing reservoir is a work of art, covered with glazed tiles over pressed brick. These works altogether have made Buenos Aires one of the healthiest cities in the world, as the death rate proves.

Ten years ago, upon the completion of the main works, the mortality per 1000 was 30; now it is 16½. This compares very favorably with other large cities. London has 19.2; Glasgow, 21.6; Liverpool, 26.3; Manchester, 24.1; Dublin, 30.4; Paris, 20.1; St. Petersburg, 24.7; Vienna, 20.7; Madrid, 30.1; Rome, 17.6; Venice, 22.8; New York, 19.7; Philadelphia, 17.7; Brussels, 17.9; Boston, 19, and New Orleans (white), 17.9.

The Government is soon to extend the works at a cost of $5,000,000 (gold).

The climate, taking the whole year round, is very equable and very agreeable. The parks are always green; vines and palms and a species of banana plants are seen everywhere, and flowers all the year in the open. It has a semitropical country in the north and in Paraguay from which to procure the plants, where the Victoria Regia and other beautiful plants grow wild.

In reference to education, the primary education is compulsory from the age of 9 to 14; secondary education from 14 to 19 is optional, as also the university, or higher education, from 19 to 25 or 26. No man can enter into any of the professions, including engineering, and take a prominent position in the Government without being a graduate of the National University and having taken the course outlined in the above division of ages.

In 1900 there were 450,000 pupils in the public schools, which are free to all, and free to people of all religions. Although the Catholic religion is the national religion, neither it nor any other religion is allowed to be taught in the schools.

In the National University there are four faculties—law and social science, medicine, exact physical and natural science and philosophy and letters. In 1901 there were 3562 students in the University.

In reference to religion, everywhere in Argentine, under the Constitution, all may worship God freely, according to the dictates of their own conscience. While the Government itself, like the Governments of Great Britain, Germany, Switzerland, etc., recognizes an established church and assists in its maintenance, it also often assists in benevolent and educational work undertaken by other denominations.

Argentine is made up of many nationalities. According to the census of 1895, there were in the country about 3,000,000 Argentines (all children born there of foreign parents are Argentines) and about 500,000 Italians—by far the largest number of immigrants—and they are far better than the immigrants of the same nationality that come to the United States. Some of the best and

most intelligent people in all kinds of business and industries, especially in agriculture, are Italians. Next come the Spaniards, about 200,000; next the French, somewhat less than 100,000; next the English, 22,000; next the Swiss, 15,000, and lastly the North Americans, as we are called, 1400. These figures refer to the year 1895; the number of foreigners in the country December 31, 1899, was 1,199,808, an increase of 20 per cent. on the returns of the year 1895.

Immigrants in 44 years			1,935,077
Italians	"	"	1,198,550
Spaniards	"	"	361,079
French	"	"	162,636
British	"	"	34,031
Austrians	"	"	31,698
Germans	"	"	27,834
Swiss	"	"	24,873
Belgians	"	"	19,082

In addition to telegraph lines, there are four cable companies working with Europe and the United States, keeping up a close connection with all parts of the world. The service is very good and prompt; its time of transmission between Buenos Aires and London, "via Galveston" and Western Union lines and cables, is about 60 minutes, and with New York 30 minutes. When we consider the distance and the route, we are astonished at the working of this line, which crosses over the Andes 12,000 feet above the sea level, tunnels under the snow and avalanches and reaches the Pacific Ocean, only to take successive leaps by loops along the coast to Tehuantepec, in Mexico; over the Isthmus, across and under the waters of the Gulf of Mexico, to Galveston, speeding then its swift flight over the poles of the Western Union to New York City; and then, without stopping to rest, plunges into the depths of the Atlantic Ocean and talks to the receiver in London in 60 minutes after it left the operator's fingers in Buenos Aires. By a wonderful invention of recent years, this message has passed from ocean to land many times and back to ocean without stopping, through a "human relay"—a machine worked by a human.

It is an interesting fact that the difference in level between the highest point on land of the lines of the Central and South American Telegraph Company and the lowest point of its cables in the Pacific Ocean is about 31,000 feet—6 miles.

This company has three underground cables which cross the Andes and work uninterruptedly, notwithstanding that they are covered with snow, in some places at great depth, for about eight months of the year.

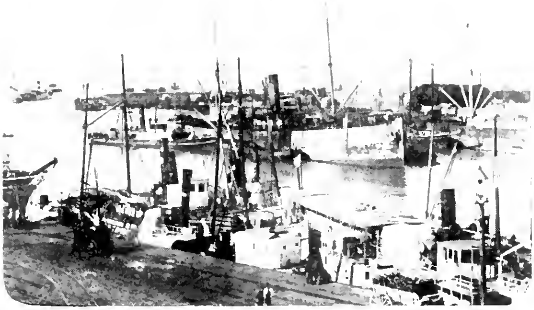
After stating these general characteristics of the country and of the capital city, I must give you a brief *résumé* of the ocean commerce, which has done so much for the country, and, situated as it is at the antipodes of the world, so necessary. First, a few dry facts, and then the description of commercial facilities.

In 1899 the value in gold of goods imported was about $117,-000,000; exported, $185,000,000. Of these, $44,000,000 imports came from Great Britain and $15,000,000 from the United States; Italy comes next, with $14,000,000, and Germany next, with $13,-000,000; then France, with $11,000,000, and Belgium, with $9,-000,000. But exports show a different distribution, for France took $41,000,000; Germany, $29,000,000; Belgium, $24,000,000; Great Britain, $22,000,000; the United States, $8,000,000, and Italy, $5,000,000. Of the foreign trade, Buenos Aires had 87.2 per cent. of the imports; Rosario, 8.8; La Pata, 1.2, and Bahia Blanca, 0.8. Of the exports, Buenos Aires had 55.5 per cent.; Rosario, 18.4; La Plata, 2.3, and Bahia Blanca, 7. These ports are mentioned because some information about them is needed to explain the commercial situation. Of all the goods reaching the River Plate countries, 80 per cent. goes to Argentine.

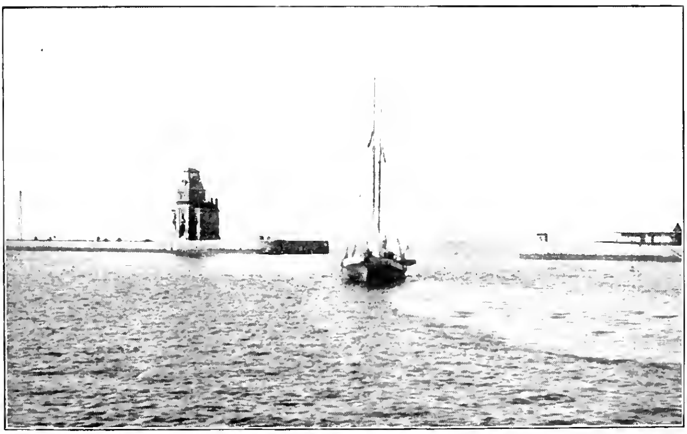
In 1885 the National Government began the construction of very large docks at Buenos Aires; hitherto all the business had been done from the anchorage, about 12 miles from the city, the intervening space being a great mud bar, the water from a depth of 25 feet gradually shoaling to the shore line at the city. This was so flat that it was necessary often to transfer the passengers and goods from the lighters, with which they had come thus far from the vessels, to small boats and to great wheel-carts that went out a long distance in the water to meet the lighters.

The new docks are very extensive, and lie along the immediate front of the city and connected with it; they were designed by the well-known English firm of engineers, Hawkshaw & Hayter, and carried out under the supervision of Mr. James Dobson, the resident engineer, and a member of the firm. The concessionaire was an Argentine citizen, Mr. Madero; the contractors were the experienced English firm of Walker & Co., who built the Manchester Ship Canal. These men all deserve the highest credit for carrying through, under the financial difficulties of the period above mentioned, a great public work, costing $38,000,000 (gold).

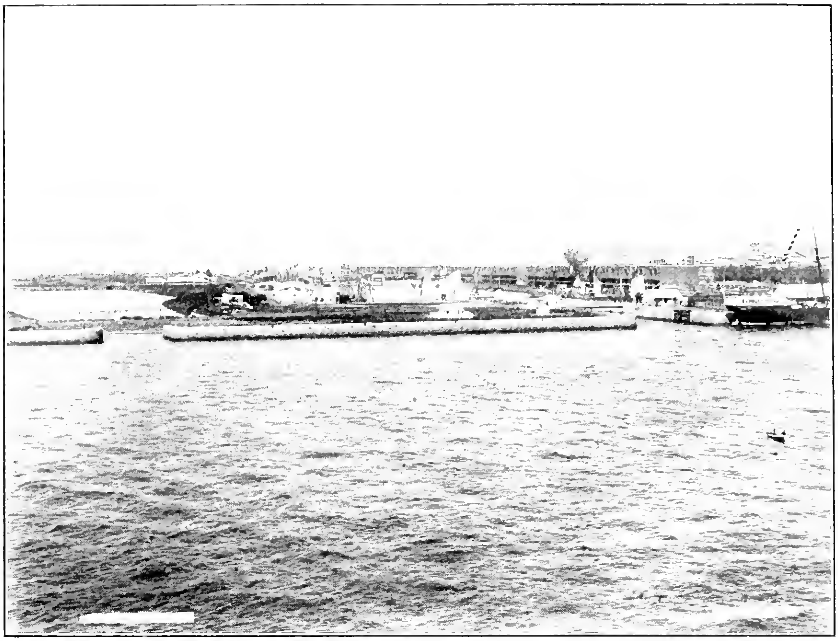
In order to reach the docks from the sea, a channel had to be excavated in the mud foreshore from the anchorage. This channel (the north one) is, at low tide, 21 feet deep and 330 feet wide, and about 5½ miles long from its intersection with a channel which



THE RIACHUELO IN 1901.



ENTRANCE OF NORTH BASIN.



View of Docks from the North Basin.

One of the Four Docks.

already existed by previous dredging from the other end of the port, at the mouth of a small, sluggish stream called the Riachuelo, in which channel there generally is about 19 feet of water at low tide. The tide of 2 or 3 feet, depending largely upon the direction and force of the wind and very uncertain, permits vessels drawing about 23½ feet to enter the port by the north channel. The new port was connected with the older port, and now both channels are being used, and the depths in them are about as I have stated.

The Government has recently extended the north channel straight out to the anchorage. The depth of water in the northern entrance basin of the port is 21 feet, but in the four great docks 23 feet, with tidal gates, so that the vessels at low tide may be afloat.

The works are built in the most substantial manner—masonry walls founded on what is called "tosca" (loess), the hard substratum that is found in this part of the country. The four docks, or basins, are from 620 to 750 yards long, and are all 170 yards wide, connected by passageways 22 to 27 yards wide, over which passes by means of hydraulic turning bridges, the foot, vehicular and rail traffic. A sea wall in front protects the entire port. On the city side are three- and four-story brick warehouses, twenty-four in all, with a total frontage of 1½ miles. Sheds, cattle yards, railroad tracks, hydraulic cranes and capstans and other important appurtenances give the port modern facilities for handling cargo.

When the docks were opened at the southern end, in 1899, the registered tonnage of vessels arriving and departing at the port of Buenos Aires was 3,800,000; in 1901, 8,661,299, more than 100 per cent. increase. There are only twelve ports in the world of greater tonnage, and none of them shows such phenomenal growth.

In 1880, about the time that the works were proposed, the tonnage was 644,570, and the plans were made for 2,000,000 tons only.

The extraordinary growth of the commerce has made it necessary to make an enlargement of the facilities, and this was one of the works intrusted to me during the last year of my stay in Argentine. I am able to show you the general plan of the actual port, with the proposed enlargement, which will have free access from the sea and a depth of 26 feet.

The plan also provides facilities for "inflammables"—coal, petroleum, gasoline, naphtha and some explosives.

The work of enlargement of the port is divided into sections, so that it can be carried out section by section, as the increase of

commerce will require. The general plan also includes the protection and deepening of the entrance channels.

One of the principal ports of the country is Rosario. Ocean navigation reaches it, and, for that matter, reaches Colastiné, the port of the city of Santa Fé, the capital of the Province. The registered tonnage of the port of Rosario in 1899 was 3,000,000, of which more than 2,000,000 were over-sea vessels, about 700 per annum. The merchandise entered and cleared was about 1,650,000 tons; 67 per cent. of the exportation was wheat. In the busy months there are often over thirty vessels seen at one time along the wharves and the barranca, where the wheat is loaded in bags, sliding down from the high cliff 60 feet above the vessel, in what are called "canaletas." The imports amount to about $10,000,000 (gold), and the exports to $30,000,000.

The National Government is making a great port of Rosario, endowed with all modern facilities for handling cargo. It sent out to Europe and the United States a full report with all necessary data, submitting the project to capitalists and contractors, with the request for propositions to build and operate the port. It will cost from $10,000,000 to $12,000,000 (gold).

The contract, after an examination of and report upon the projects presented by a Board of which I had the honor to be President, has been let to the well-known and experienced firm of contractors, Messrs. Hersent, of Paris, associated with Schneider & Co., of Creusot, the Krupp of France. The works of construction were inaugurated by the President of the Republic on October 26, 1902.

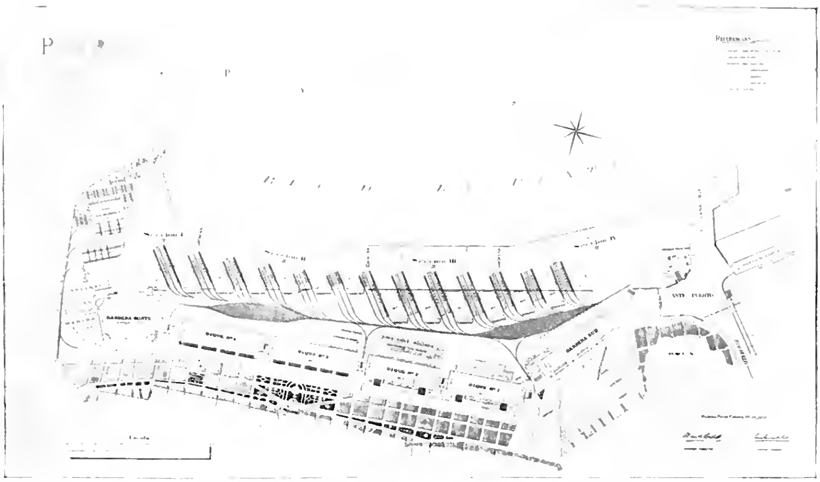
The plans of the work have been based on the data above mentioned.

Some important problems had to be solved in connection with the improvement of so great a river as the Paraná, the bed of which is subject to such important changes, and also its islands and banks.

The front line of the proposed wharves is over 2½ miles long. The masonry piers must go down into the tertiary sand below the scour of the river, and their foundations will be from 60 to 80 feet below the low-water level.

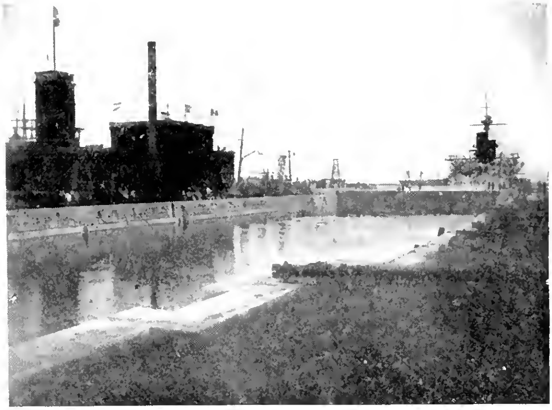
The importance of this work, furnishing a modern seaport to the second city of the country, can scarcely be overestimated. In my report on the project, made in September, 1900, I used the following words, which two years of subsequent study have corroborated:

"It is safe to say that the establishment of a first-class port

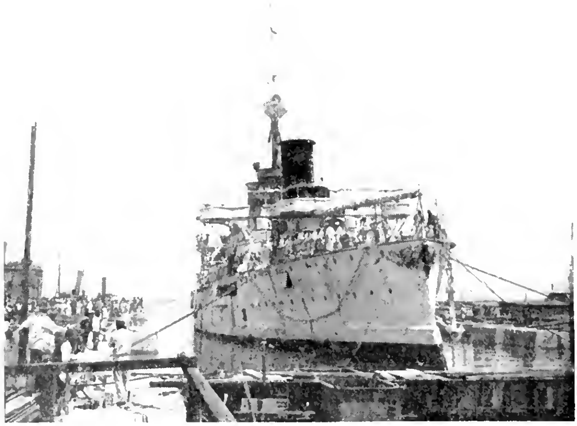


Port of Buenos Aires and Plan of Enlargement.

The Dry Dock.



President Roca Inaugurating the Dock.



The "San Martin" in the Dock.

at Rosario, with suitable channels of access, will revolutionize completely the commerce and industry of this Republic."

La Plata port and city were built by the Provincial Government, when, in about 1880, the National Government came to Buenos Aires to occupy it as the capital of the nation. It is an excellent port; it is built on the shore of the Rio de la Plata, about 35 miles from Buenos Aires, and cost about $14,000,000 (gold). The opening of the national port at Buenos Aires has driven most of the commerce from La Plata, but it is capable of being made, with a comparatively small sum of money, deep enough, in its entrance channel (5 miles long) and in its port areas, to accommodate vessels of 26 feet draught at low tide; it now has 21 feet.

The remaining port of importance and rapidly growing is outside of the River Plate, in the south, Bahia Blanca; it is the principal shipping port of agricultural products by the Great Southern Railway, the largest system in the Republic. This port is in an estuary of the ocean, and is a protected harbor; in fact, the terminal of the railway is about 35 miles from the open ocean. The railway is building a steel pier, 1640 feet long, with spacious warehouses and 19 miles of siding; and there will be, when all the works are completed, over half a mile of wharf frontage, supplied with electric cranes.

The National Government is building in this estuary at Puerto Militar, or Puerto Belgrano, a system of dry docks and basins on a large scale. The first dry dock, one of the best and largest in the world, is completed and now in use. It was designed and built under the immediate supervision of the well-known Italian engineer, Chevalier Luigi Luiggi, who had charge of similar work at Genoa.

This dock, built of first-class materials and upon the most modern methods, can take the largest naval or merchant ships of the world, as it has a useful length of 713 feet and an entrance width of 85 feet and a depth over the sill of 32½ feet at mean high tide, 22 feet at low tide. It has intermediate gates, so that two or three small vessels can be docked at the same time or separately.

I cannot here go into details of construction, which were fully given in a paper on the subject submitted by Mr. Luiggi to the Ninth International Navigation Congress at Düsseldorf, July, 1902. He has very kindly given me over thirty lantern slides, of which I can show you a few, to give you a general idea of the dock. The plans, photographs and, possibly, a relief model of the dock will be exhibited at the World's Fair in St. Louis, in 1904.

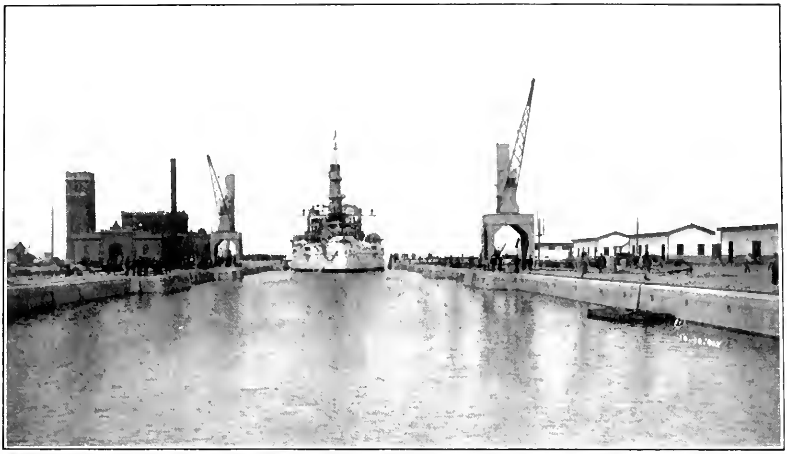
In October last the United States battleship "Iowa," the flag-

ship of the South Atlantic squadron, was docked at Puerto Militar.

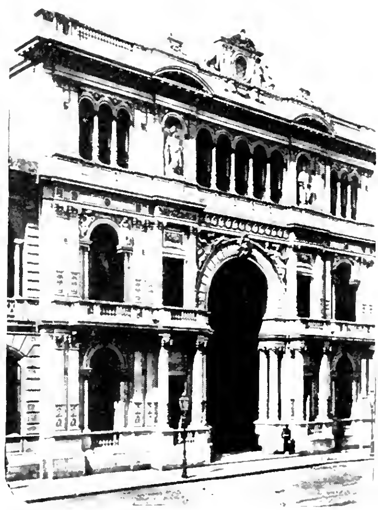
You will be interested to know that at Buenos Aires there is a large business with New York by means of five steamship lines, and, through New York, with other cities, from which are shipped a large amount of agricultural machinery of all classes, from cultivators and plows to great steam threshing machines of the "J. I. Case Company," of Racine, Wis. From all manufacturing districts the trade of our country is increasing. You see our machinery everywhere, and it is everywhere considered equal to any—Baldwin locomotives, Jackson & Sharp cars and Harlan & Hollingsworth's. The American freight car of 25 and 30 tons is replacing the old Belgian, French and English 7- and 10-ton cars. If the American cars are not all made in the United States, they are copied from ours. The most approved bridges are from the United States. I have been over several and examined one on the Transandine Railway, built by the Phœnix Bridge Company, of Philadelphia, excellent bridges and giving entire satisfaction. The Boston Bridge Company sent out some very good bridges. The horse cars by John Stephenson & Co., of New York; electric cars by the J. G. Brill Company and the Westinghouse Company are doing well there. Large quantities of Southern and Oregon pine are imported. From the United States comes all the kerosene used in the country. I might go on enumerating many other United States products. I can well say that the prospects of American trade with Argentine are exceedingly good.

The Argentine Government is determined to improve the great rivers of the country by methods which have been found to be best in other countries under similar conditions. The results of our experience upon the Mississippi are being closely watched, studied and applied. The reports of the Mississippi River Commission are of great value to that country. I may further say that the engineers and the methods pursued by them are equal to those of any country. Every Government engineer, to take a prominent position, must have a diploma from the Engineering Department of the National University. The graduates of this excellent school are as well equipped for their work as those from any school in the world; this I know by experience, for four of them (young men) have been associated with me as my immediate assistants, and, in my position as Consulting Engineer of the Government, I have been brought into close relations with many other engineers, and I have the highest opinion of their ability.

The Government Building—Casa Gobierno—sometimes called

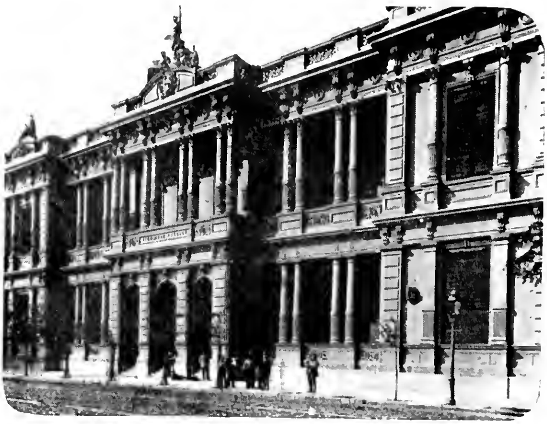


U. S. Battleship "Iowa" Entering the Dock.



Entrance of the Government House.

THE "PRENSA" BUILDING.



THE SARMIENTO SCHOOL.

the "Casa Rosada," from its light rose color, and in which was my office, is one of the most prominent buildings in Buenos Aires.

It stands in a prominent and central position, facing the Avenida de Mayo, and looking out on the other side over the port and the River Plate.

One of the finest structures in Buenos Aires is the "Prensa" Building, devoted entirely to that morning paper. I know of no newspaper offices in the world that can compare with this in elegance and convenience in all its interior appointments.

The leading newspapers of Buenos Aires are equal to any, both in editorial ability and in telegraphic news from all parts of the world.

The Sarmiento School gives me an opportunity to call your attention to one of the most learned and best of Presidents, who, when he was Minister at Washington, became so interested in our educational methods that he engaged a large number of our young lady teachers to go to Argentine as normal school teachers. Many of them are there yet, after nearly twenty years' service—a service that has reflected honor upon themselves and their country.

You may properly ask me why I have brought before you the subject of Argentine. I can easily reply—first, because in two years of close relations with the country, and especially with the Government officials, I formed a very favorable idea of the character of the people and of the possibilities of business and profitable enterprise for our own people there; and, second, because the high officials of the Government and leading men of the country desire to have the "Norte Americanos," as we are called, come to Argentine with their business energy, integrity and ability, and their capital as well, to help build up and move forward to its high destiny that great country of South America, so like our own in its climate, soil, rivers, coast line and other general features.

If I have succeeded in interesting you in Argentine, and in giving you more knowledge of it than you had before, I shall be satisfied with my efforts and feel that I have done a service to that country and to my own.

RICE IN TEXAS AND LOUISIANA.

By Francis M. Henry, Associate Member of the American Society of Civil Engineers.

[Read before the Engineers' Club of Minneapolis, February 27, 1904.*]

The cultivation and use of rice as a food antedates authentic history.

"It is mentioned in the Talmud, though neither in the Old nor New Testament. It was certainly known to the Romans; was set forth in the tragedies of Sophocles, B.C. 495. It was described by the Greek philosopher Theophrastus, B.C. 300. Legend places its introduction into China, B.C. 2822. It had undoubtedly spread throughout the tropics long before the commencement of the Christian era."

One-half the population of the earth use rice as their principal food. It has been selected as the staple wherever climatic conditions permitted its cultivation. As certainty of supply is of first importance among most dense populations, the dependence on rice, in such closely settled lands as Japan, China and India, is easily explained. The Chinese Empire, with 400,000,000; the British possessions in Asia, with 300,000,000; Japan, with 40,000,000, and other islands and nations aggregating about 100,000,000—of these 840,000,000 rice constitutes the principal food supply.

"Rice is raised in China, Japan, India, Ceylon, Siam, French Indo-China, the Straits Settlements, the Philippine Islands, Persia, Asia Minor, Africa and the islands of the Indian Ocean, Egypt, Senegal, French Sudan, Algeria, Tunis, Madagascar, Honduras, the Hawaiian Islands, Brazil, United States of Colombia, Peru, Australasia, the Pacific Islands, Australia, France, Italy, Spain, Mexico and the United States."

In China, the cultivation of rice extends all over the eastern and southern portions of the Empire. Lowland and upland rice are both cultivated, but, in spite of the great area cultivated, the product often falls below the home demand, and it is imported from Siam and the Malay Islands. The exportation has, upon occasions, been forbidden for several centuries.

The rice lands in China are generally in the hands of large proprietors, and by them leased to farmers, or land gardeners, for each man usually cultivates a lot of not more than a half to two-thirds of an acre, and frequently less. They pay a rent which is equivalent to from $7.00 to $10.00 per year, the landowner taking

* Manuscript received March 18, 1904.—Secretary, Ass'n of Eng. Socs.

about one-fifth of the crop, though frequently a full half falls to his share.

The most primitive implements, and those that have been in use for a thousand years, are to-day found in China. Chinese conservatism distrusts any innovation in the way of modern instruments or machinery. The hoe and spade and sometimes the wooden plow, shod with iron, are the only implements used. Fertilizers are used and held in great faith. As the country abounds in rivers and small streams, canals are taken for irrigation, though regularly organized systems, such as are in Japan, do not exist. In some localities, away from a natural water supply, the rice growers unite and convey water to the fields, raised by water wheels and driven through bamboo pipes. Hillsides and slopes are terraced that the fields may be level, and are so arranged that after a sufficient depth of water is supplied to one terrace, it will flow upon the next field, and from this to the third, and so on, to the lowest level.

"The rice is first soaked in water saturated with some fertilizer known to them, and this forwards the growth so much that young plants, after being deposited in the earth, appear above the ground in two days. As soon as they have reached the height of 6 or 7 inches they are pulled up, the tops cut off, the roots carefully washed and the whole planted out in rows about 1 foot apart. While growing, it is sprinkled with lime and water, to destroy insects and assist in enriching the soil. The first crop, for the Chinese in some localities obtain two in the course of a year, is harvested in May or June; the second, in October or November. The sickle is used in reaping, and resembles the European instrument, but, unlike the latter, it is notched like the teeth of a saw. The straw and stubble are burned and left upon the spot to enrich the soil. The Chinese have long been accustomed to improve their rice by the selection of seed, and this is enjoined by imperial edicts." Harvesting and threshing is done after very ancient methods. The rice is cut with a sickle and threshed by treading with oxen or by the flail. Another way of threshing is by beating the heads of the grain against the edges of a box into which the paddy falls. Pouring the grain from baskets in the wind, or fanning with large paper fans in the absence of a breeze, constitutes their winnowing process. It is hulled by crude mortars and pestles. The best fields will average, it is said, about 4000 pounds per acre, or 2000 pounds at each crop, which would be equivalent to about twelve sacks per acre per crop.

It is said rice land in China sometimes is sold for a price equivalent to $300.00 or $400.00 an acre.

In Japan the plow is rarely used; the soil is dug with a mattock,

and an implement similar to a harrow is frequently employed to pulverize it. Sometimes this is drawn by an ox or horse, but more frequently by manual labor. As in China, they pay particular attention to fertilizers, and sow the rice broadcast, and afterward it is transplanted in rows. An essential difference, however, is that in Japan mountain streams have been directed to supply large and substantially built irrigation works, and great districts are often traversed by canals, winding around the mountains, and thus equalizing the water supply for the crops throughout the year.

The average yield of rice in Japan is equivalent to sixteen sacks per acre, and the selling price about $2.40 per sack, and the rice, as to quality, second to none. The progressive Japanese, of late, have been continually sending agents to the United States with a view of bettering their systems of rice culture, and although the Government tax on rice is very high, the edict forbidding its exportation has been repealed, and we may expect great advances in rice growing in that country.

In India the number of acres cultivated in rice reaches something over *sixty millions* in an average year. It forms the principal food of that vast population, estimated to be 20 per cent. of the people of the world. It is the crop of greatest importance. All sections of the country produce it; all varieties of soil yield it, and under widely differing conditions of climate, altitude and water supply. It is estimated, in India, that 1400 varieties of rice are now to be found.

In the space of this brief paper, it will be futile to attempt the enumeration of many of the different varieties or to describe the various modes of cultivating rice in India. "Thus in Bengal much dependence is placed upon the rainfall for one variety which is grown on the light, sandy soils not using irrigation, while another grows upon the low alluvial tracts and is irrigated; in a different section the rice grown is of the red variety of lowland rice, where dependence for irrigation is placed upon the influx of sea water. The fields being diked, the sea water is drained out at low tide, and a herd of buffaloes are hastily driven over every portion of the field and the seed placed in the tracks made, the members of each family being then obliged to stand guard on the dikes built to preserve the precious seeds from air fowl till the growth has started."

In still another section, "The water is drawn off the land, and the head of the house, with his entire family, joins in a frolic, until the whole field is reduced to the consistency of liquid mud, into which the seed will sink of its own weight upon being scattered."

"While in Nepál, the Joomla rice, an upland variety, 'flour-

ishes without inconvenience amid the snows and frosts of the Himalayas, at elevations of from 6000 to 7000 feeet (and it is interesting to note that this latter has been successfully raised upon the banks of the Thames in England.)"

It is safe to say that the primitive methods of rice raising existing in China and Japan have not been improved upon by the rice growers of India.

The Philippine Islanders cultivate rice after quite as primitive a manner as the above countries. The home production is inadequate and large quantities are annually imported. The Hawaiian Islands, Porto Rico and Cuba all import rice.

Passing a further description of the methods employed in the cultivation in the remaining various countries before named, as they are all more or less similarly primitive, and considering at once the history of this cereal in the United States, we find that "early in the eighteenth century an alleged East Indian man was blown ashore on the stormy coast of Carolina, and it happened that part of the cargo was saved, and one small package fell to the lot of a French Huguenot refugee, who had fled from the turmoils of France and settled on the Atlantic shores of our southern colony. This colonist recognized in the little brown seeds, that his fellows mistook for barley, the *great East Indian staple—rice*. He planted it in the low, marshy river bottom and, in time, a crop was harvested."

From this small beginning the rice industry of South Carolina grew. For 190 years after the introduction of rice in the United States, South Carolina and Georgia produced practically all that was raised.

The lands used for rice culture in these States were low and marshy, and bordered on the rivers emptying into the sea. The irrigation of the land was obtained by diking the fields adjacent to the streams and allowing the same to be flooded by the back water at high tide and the water taken off, or the fields drained, by opening the gates, with the ebbing tide. "The sediment carried in the Savannah, Combahee, Ashepoo, Edisto, Cooper, Santee, Sampit, Pedee, Black and Cape Fear Rivers greatly enriched the soils they flooded, while many times a heavy freshet upon one of these, being met by a storm from the sea, has wrought great havoc."

In these States rice was seldom grown within 15 miles of the sea, or more than 30 miles from it. This 15-mile belt was fixed, on the sea side, by the presence of salt water in the river, and on the land side by the point at which there was not sufficient difference between high and low tide. A 2-foot tide has been taken as the minimum for drainage and irrigation purposes. Great canals con-

nected remote plantations with the tide streams. The methods of irrigation were crude, and to-day the systems of the colonial planters are still in use. The rice is drilled in rows, 14 inches apart, and sometimes immediately flooded to protect the grain from birds, the water drawn off and not put on till the plant has reached 5 or 6 inches, then the "stretch flow" is put on for several days, after which follows the "dry growth," which lasts some forty-five days, and, in well-drained fields, the crop is cultivated during this period by horse and hand hoes. Rice cannot be grown successfully in these old States without cultivation. The soil is such that water cannot take the place of hoeing. Also, the conditions are not suitable for harvesting machinery. The sickle is used, and colored men and women cut, tie and cock the grain.

From 1847 to 1861 the average yield of the United States was 116,000,000 pounds of cleaned rice. The period of the Civil War diminished this to an average of but 2,000,000 pounds. "The industry had been remanded to its infancy. The long abandoned fields had grown up in a tangle of brush, vines and trees; the once disciplined and supremely efficient labor of the country had turned into a mob." Many failed, and few who undertook to renew their old-time calling succeeded, because of the changed conditions.

After 1861, however, *Louisiana* began to come into importance with her rice crop; so that in twenty years, or in 1881, she produced as much as all the rest of the United States combined, and in 1899, out of 137,000,000 pounds of cleaned rice, Louisiana produced 108,-000,000 pounds.

It is interesting to know that during this same year, 1899, the United States imported 153,837,000 pounds of cleaned rice, or 16,-837,000 pounds more than she produced. Let us look for the reason of Louisiana's wonderful growth in rice growing.

"Longfellow and George W. Cable have made the world acquainted with the French settlers of Nova Scotia who, driven from their homes, have borne exile in Louisiana for the past 150 years. These farmers depended chiefly upon their herds of cattle feeding in the upland prairies, though simple farming was carried on, and rice, among other products, was raised. There were few wants the country did not plentifully supply."

These Acadians, in raising rice, depended solely upon the rainfall to flood their crops. Irrigation was unknown to them. "From a commercial point of view, their rice crop was insignificant and their methods were too primitive to admit of progress." Hence, for 100 years preceding the Civil War, the rice industry in Louisiana remained stationary. After this date, however, men of more

ambition went to Louisiana and experiments soon began to be made. They stored water and raised levees about their fields. Presently they discovered that the great prairies adjoining and between the "bottom" lands could grow better rice than the bottoms themselves, when there was plenty of rain. The problem then was to raise water to flood these prairies. Small steam pumps were first employed to raise the water from the bayous, but it was not till 1896 that the first real success was attained by the use of a centrifugal steam pump, 2 miles northwest of the town of Crowley, in Acadia Parish, La. Its operation during the summer of that year marked a new era in rice cultivation.

The result of successful irrigation on prairie lands caused a rapid rise in the value of such lands and brought them immediately in demand. As this success became known and fully substantiated, the area for rice culture extended, until a vast territory was included.

Following closely upon the heels of prairie irrigation came the discovery that rice could be harvested by the same machinery that harvests wheat, that the same drills could plant it in the ground and that the soil of these prairies could be kept free from weeds by water, and hence no cultivation was necessary after the crop was seeded.

Another most important discovery came about this time, in the ascertaining of the existence of an immense underground reservoir or stream underlying the whole country, in what is now known as the Louisiana and Texas rice belt. This subterranean lake or river, for it seems to flow slowly toward the Gulf, is found in a great sand and gravel water-bearing stratum lying from 12 to 20 feet below the surface, and it has been ascertained to be practically inexhaustible.

These last discoveries immediately made it possible for great profits to be obtained in rice cultivation; it plainly showed "that the immense coastal plains had found their redemption, that this cereal was to rescue them from the reign of the steer" and turn the country into a most thrifty agricultural section.

To-day, the rice belt, or the district where rice can be raised after this fashion, covers in extent about 250 miles in length by 40 miles in width. It extends from about the 92d degree of longitude in Louisiana on the east to the 98th degree in Texas on the west. On the south it is from 20 to 35 miles from the Gulf, and on the north from 60 to 75 miles.

The country near the Gulf is, for the most part, a low swamp, occasionally flooded by the sea when strong offshore winds prevail;

but back of the swamp district lie the great prairies sloping toward the Gulf, falling about 2 feet to the mile and interspersed with stretches of timber on the "bottoms" along the streams. To the eye the country is most beautiful, for a prairie district, and it differs from our northwest prairies in being a luxuriant green, because of the sufficient rainfall, and also in always having as a background a bank of tall timber outlined against the sky.

The soils in Louisiana are mostly lighter than in Texas, being for the most part of a sandy loam, underlaid with a clay subsoil. In the rice district in Texas the "black waxy" and "hog-wallow" lands are the most sought after, though the sandy loams underlaid with clay are also used. The "waxy" or "hog-wallow" lands are impervious to water themselves, besides having the clay subsoil, and these latter yield enormous crops and require no fertilizers. The "bottoms" lying between the prairie stretches and along the streams have been in cultivation for many years, and cotton, corn and cane are the great staples raised thereon.

To-day the negro labor in this district is confined to the bottom-land products, viz., cane, cotton and corn, and the white man alone is found on the prairie with the rice, the reason being that the former is as yet unfit, as a whole, for the running of machinery, etc., or for any form of labor differing from that to which he has for generations been accustomed.

The methods of raising and distributing water for irrigation purposes in use to-day in these two States are as follows: Irrigation companies controlling and owning large bodies of land, running all the way from 500 to 10,000 acres, raise, by huge centrifugal pumps which are driven directly by powerful steam engines, vast quantities of water from the bayous and rivers, and discharge the same into the great canals, which, in turn, distribute the water by laterals, sometimes alone by gravity and sometimes through the aid of a second or third lift (as the different pumping stations are called). These great centrifugal pumps, some of them discharging a stream 6 or 8 feet in diameter, have the enormous capacities of from 50,000 to 75,000 gallons per minute. Frequently these companies have three or four of such pumps lifting water from a river or bayou into the irrigating canal. Such companies make contracts with rice farmers, whereby they agree to furnish land and water for a consideration of two-fifths of the harvested crop, the farmer simply furnishing the seed and necessary labor to grow and harvest the same.

The other system of rice growing is that of the independent

landowner, who irrigates his land by pumping water from his own well. He plows when it suits him best, disks, seeds, irrigates, drains the land and harvests his crop when, in his own judgment, it is best for him to do so, and has nobody but himself to blame for the results.

He can obtain sufficient water to irrigate 100 acres from an 8-inch well, 100 feet deep, and by attaching a centrifugal pump, driven by either a gasoline or steam engine, he is insured more constant success than in any other agricultural pursuit.

This last system is fast becoming very popular, and deservedly so, as its advantages can be easily appreciated. American farmers like to own their own land. This is part of their nature. The artesian water is free from all impurities, seeds, etc., carried in the river water. The farmer can get the water the very day and hour that his crop may need it, and, also, it can be drained off at his will. He is embarrassed by no long delays and broken promises for water on the part of some big irrigating company. It is his own fault if he does not raise a crop. The greatest successes have been attained by individuals using the well system.

Let us look into the financial end of one of these farmers using the well system.

The First Year He Pays

For 100 acres at $40.00	$4,000.00
" building levees (at $1.50 per acre)	150.00
" well and pumping plant, complete	1,500.00
" house, barn, etc.	1,000.00
" breaking	250.00
" disking	150.00
" seeding and seed	250.00
" irrigating	300.00
" harvesting	240.00
" threshing and sacks	494.00
Total first year's expense is	$8,334.00

Taking an average yield of fifteen sacks per acre and the average price of $3.00 per sack of rough rice of 162 pounds, we have as the gross receipts of this first year $4500.00.

A man to start a 100-acre rice farm should have capital at his command sufficient to carry him safely through the first year. Should one be in such shape and be otherwise fitted, the results of the second year would be as follows:

Plowing	$100.00
Disking	100.00
Repairing levees	25.00
Planting	100.00
Seed	150.00
Harvesting	240.00
Threshing	494.00
Irrigating	300.00
Interest on investment at 5 per cent	332.50
	$1,841.50
1500 sacks at $3.00	4,500.00
Net profits, end of second year	$2,658.50

Compare the above with the renter from an irrigation company.

SECOND YEAR.

Plowing	$100.00
Disking	100.00
Repairing levees	25.00
Planting	100.00
Seed	150.00
Harvesting	240.00
Threshing	494.00
	$1,209.00
1500 sacks, total crop	
Less 2/5 for rent, 600 "	
900 " at $3.00	2,700.00
Net profit	$1,491.00

I have in mind a man named J. W. Leach, in whose house I have been and whose farm I have inspected, and who the first year, on 160 acres, with two wells, raised 2268 sacks of "Honduras," that sold for $3.20 per sack of 162 pounds each. This man is a native of Illinois, and the above was his first crop. He told me his gross receipts, straw and all, this year were $8375.40. His entire outlay, land and all, was less than $10,000.00.

If the work of irrigating is excepted, the process of raising rice is practically the same as wheat or oats in the North.

The land is plowed with gang plows, in the fall or spring, sometimes both, then disked and harrowed thoroughly. Planting is sometimes done with a broadcast machine, coupled to a farm wagon, or, more often and better, it is drilled in rows 7 or 8 inches apart. The planting season extends from April 1st to June 15th, or sometimes later.

Dependence is placed upon the rainfall altogether to start or sprout the seed and promote the growth of the plant for a period varying between one and two months. Flooding generally begins when the plant has reached a height varying between 6 and 10 inches, and from this time till the grain is in the milk and well formed, a space of about seventy days, the fields are kept flooded.

A couple of weeks before harvest, the levees are cut and the fields drained, and the grain rapidly hardens and matures, so that, by the time the field is ready to cut, the ground is dry enough to permit the heavy threshing machines to be used. These are sent into the fields and the rice is cut and bound and put into cocks, where it is left for a period to thoroughly mature.

The manner of threshing is precisely the same as in the case with wheat, excepting that rice, upon being threshed, has still a hull on it, and also, that instead of being handled in bulk, as in wheat, it is *always* handled in sacks. Upon threshing the rice in the fields, "rice buyers" from various different rice-mill companies make the farmers cash offers. Last season's prices ranged from $2.50 to $3.50 per sack of 162 pounds, depending upon the quality of the rice. Unlike the wheat business, there is no regular grading of the rice before it is hulled. Most of the rice raised in this section is "Honduras," although "Japan" seed has been planted with great success. The degree of whiteness and weight determines the value of the rice.

The great inconvenience and expense to the farmer in sacking all his rice, also the extra work and bother in transferring the same at the mill, occurred to me to be a most useless piece of business, but various reasons were offered why rice could not be handled in bulk by elevators, the sum and total of which were that it had never been done, that "*sacks had always been used.*"

The writer, while in that country, has often criticised the old sack system, and has advocated the building of elevators, and it is with satisfaction that it has been noted in the *Houston Post* that this very thing is about to be done, *i. e.,* that a great chain of elevators for rice is to be constructed. This last step will save at least 20 cents a sack to the farmer.

As already stated in this paper, the total yield in the United States in 1899 was 137,000,000 pounds; in 1900 it grew to 219,278,-000 pounds. For 1901 it was 253,139,000 pounds, and 1902 advanced the figure to 390,000,000 pounds, an increase over the previous year of as much as the total crop of 1899.

The acreage devoted to rice growing for 1902 is placed at 400,000 acres, and the estimated available acreage as yet untouched

may bring the total to 4,000,000, capable of yielding some 40,000,000 sacks of 162 pounds each, or 6,480,000,000 pounds, or a crop sufficient to give to every man, woman and child in the United States 80 pounds per year.

It is interesting to note in this connection that Japan raises about $3\frac{1}{2}$ times this amount; British India, $7\frac{1}{2}$, and China, 17.

A fair conclusion would seem to be that America will soon find in rice an extremely cheap and wholesome food, and as these vast districts are devoted to its culture, the food which feeds one-half the world will become most important to us.

THEATER CONSTRUCTION WHICH INSURES PUBLIC SAFETY.

By E. O. Fallis, Member of the Toledo Society of Engineers.

[Read before the Society, March 18, 1904.*]

Why is it that this great government of ours is so careful in the protection of the rights of individual citizens, when interfered with by those of any other government, even going so far as to send men-of-war to distant waters to demand reparation for wrongs inflicted upon an individual, an obscure citizen (and that citizen sometimes an alien), while at home, the rights of one may be trespassed upon by another, or one may infringe upon the right of many in the strife and struggle for gain, even to the extent of causing the death and maiming of hundreds, and go unpunished, overlooked and soon forgotten? Why is it?

The first requisite to change this order of things is a demand from the public; and the second—an enforcement of such demand by adequate laws rigidly and continuously applied. Now let us apply this to the subject at hand:

Few, if any, theaters will ever be constructed that will insure public safety without question until the public demands it and then enforces its will. In considering the question, three factors enter into the problem: First, the public patrons; second, the ownership and management; and third, the architect and builder.

Considering the factors independently, and in the order in which they are named, we shall first discuss the public.

A catastrophe to-day shocks, alarms and disturbs the whole public; steps are immediately taken to investigate the cause and to remedy the evil. To-morrow, new subjects attract the attention of the public and, in a short time, all is forgotten. In the course of a month or two matters are much the same as before. The public crowds the various theaters indiscriminately, the cheap, gaudy, flimsy, life-endangering theaters being as well patronized as those of more costly structure, in which an endeavor to protect the public from danger by a largely increased expense in construction has been made, and with fire marshals, building inspectors and city officials sitting complacently in their private boxes in order to insure public confidence.

It is not to be presumed that the general public should be judge of the safety of buildings, of the construction of which it knows

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nothing, but it should demand self-protection through its laws and its guardians. As I have already said, until the public makes the demand and then enforces it, safe buildings will not be constructed.

As for the ownership and management, we all know that those who engage in the construction of theaters do so for financial gain, the largest receipts for the smallest investment being, with few exceptions, the sole object.

A theater of combustible and otherwise dangerous construction can be erected for not more than one-half the cost of one that is non-combustible and otherwise safe, both being of the same seating capacity and equally pleasing in design. All other things being equal, the indiscriminating public will patronize (excepting perhaps for a short period after a fatal catastrophe has occurred at some theater) the house of dangerous construction as freely as the other; consequently, the owner of the house of cheap construction will make twice as much percentage upon his investment as the owner of a house of more expensive construction. Why should an investor construct a fireproof and safe building, knowing the conditions and the field of competition against him? You say there is the moral responsibility. Yes, it is true, but among financiers and theatrical managers such is generally considered only after the fires begin to burn.

In the patrons and in the ownership of such theaters we have the two opposing forces; the public, the buyer; and the owner or manager, the seller. Until they adjust their differences, the architect, in this country, has but little call to exercise his ingenuity in devising a safe theater.

The question of devising laws having jurisdiction over private property and enterprise, and having them properly and justly administered, is a vexed one, and the results are questionable.

In many of the cities of Continental Europe, the theaters, opera houses and places of amusement are owned and managed by the municipalities, which not only protect the public from the dangers of poorly constructed houses, but afford it a higher standard of entertainment and amusement. Supposing the time had arrived when the construction of all theaters was upon the same footing—that one owner had no advantage over another, but all were compelled to build equally good structures—then the architect would be at liberty to devise the methods of construction necessary to produce the desired result.

The greatest danger that threatens a gathering, consisting of a number of people, is a panic, caused from fright and conditions that threaten their lives. The problem to be dealt with is to remove

the cause of all apprehension and to inspire an audience with the utmost confidence. To accomplish this, not only every feature that endangers life, but every feature that may cause alarm in the most timid must be removed. Danger from without, as well as from within, must be guarded against. Exits must be numerous, free and unrestricted; nothing arouses a sense of insecurity quicker than a feeling that the way of retreat is menaced or closed. Danger must not only be eliminated, but proof to the public that such has been done must be made by actual demonstrations and tests.

Having placed the problem before you as I view it, a few suggestions upon a method for accomplishing the result desired may be of interest. First, I will consider the danger from without. A theater may be within itself safe, yet it may be so confined within the walls of a contiguous building, or other buildings located so closely, as to endanger and alarm an audience in case of an extraneous fire. This also might be caused by limiting the surrounding spaces to such an extent as to cause congestion of the public ways, especially should these be already filled by an excited throng, as might, under the circumstances, be the case. To obviate these difficulties, I would erect theaters and such buildings within open spaces, such as the centers of public squares, and arrange them in such a manner that no other building would come in contact or even within a distance of 100 feet of them.

In order to discuss such a construction intelligently, it must be done from a practical standpoint, and certain statements which I make must be considered as facts, as follows: First, an isolated theater, constructed of non-flammable or non-combustible material, and in which no combustible material whatever is stored, will not of itself burn; second, the general public, when witnessing a scene depicted upon a stage, is not yet capable of drawing upon its imagination to such an extent as to supply a lack of scenery, as is the case with the theaters of the Chinese and Japanese. This being the case, it has been found impracticable in nearly all theaters to make scenery of anything but inflammable material. This granted, we must meet the practical demand, and the proposition to be considered becomes:

A theater, all parts of which, excepting the stage, are incombustible, and not subject to the heat of combustible materials; a stage, which may be combustible, and subject to highly inflammable materials. With these as the two factors, the problem becomes a question of completely isolating the theater and constructing a stage that may be completely and effectually cut off from the balance of the theater, in such a manner as to prevent the radiation of heat

or the escape of gases. To accomplish this is not a difficult task—not so difficult as many imagine, although it cannot be done without some extra expense.

There are many ways to form such a construction. A stage should, in my opinion, be considered as a huge furnace, constructed with double walls, air spaces and wickets for passage, lined with fire brick, and provided with great stacks directly over, with highly inflammable valves in each; the proscenium opening being considered the door. This should be closed, not by a great sheet, or make-believe "fireproof" curtain, that may be ripped asunder by the force of the great drafts of air, or fail under such pressure to descend to the stage floor, but by fire- and gas-proof movable walls, composed of boiler iron or steel tanks, formed in several rising sections, one sliding past another, as the space may demand. These sections could be formed like great box girders, the top flange of one hooking into a groove filled with sand, on the bottom flange of the next, and so on, the ends being confined in cast-iron grooved ways. Each tank or section should be completely filled with water, and all counterbalanced by attaching chains at several different points in their length; all operated by hydraulic pressure and worked automatically.

Or the same general scheme might be adopted and constructed of steel and porous terra cotta, or of steel imbedded in concrete. The result is: Destroy the stage, if necessary, but save the people. I am confident that a stage can be so constructed that it may be burned out without the knowledge of the audience at the time sitting before it.

A menace from fire from other sources, internal or extraneous, must be guarded against. No carpets, draperies or upholstering whatever (from a sanitary standpoint as well as from the danger of fire) should be permitted. No room or space in or about the building forward of the stage should be used for the storage of anything. No gas of any kind should be permitted within the building or its approaches. A double system of electric wiring should be used to insure against accident, each system being taken from separate dynamos.

No obstructions, permanent or movable, of any kind whatever should be permitted in passageways. Cloakrooms should be constructed on the same principle as suggested for the stage, *i. e.*, with fireproof walls, ceilings and doors, and large flues opening above the roof of the theater, that smoke and other gases might be quickly and completely carried off, in case fire should start within them.

No business whatever, other than for theatrical or similar purposes, should be conducted within or contiguous to the building. The planning of the building, the proper distribution and proportion of exits, the staircases, widths of aisles, spaces between rows of seats, as well as the various and numerous ways of extinguishing fires, I will not take time to mention, more than to suggest that, of course, it would be wise economy to employ upon the stage such fire-preventing and extinguishing appliances as may be approved. In other parts of the building such precautions would not be necessary.

ORIGIN OF THE UNITED STATES LAND SURVEYS.

By W. A. Truesdell, Member of the Civil Engineers' Society of St. Paul.

[Read before the Society, March 14, 1904.*]

There would be a good opportunity in the field of historical research for someone to write a history of the early land surveys and the origin of the system. The author who attempted it would be greatly surprised at the outset, for, in the line of special history, he would find a remarkable scarcity of material, and in official records and reports, where he would naturally look, absolutely nothing. With those who had ever considered the subject he would encounter a wide diversity of opinion, and among the men who at different times had been credited with the method there would appear the names of Jefferson, Thomas Hutchins, Rufus Putnam, Jared Mansfield, Edward Tiffin, William Henry Harrison, and Washington, for it is true that all of these men have had supporters, and evidence has been produced and arguments made to show that each of them originated the present method of United States land surveying.

At first, and for many years, it was supposed that Jared Mansfield devised the plan. This opinion was due to some very erroneous historical statements in the early editions of Davies' "Treatise on Surveying," where it was said that Mansfield alone originated the system, that no general plan had been in use by the Government before the year 1802, and one would infer from the language of the text that the method was invented on short notice and applied to immediate use in the Northwest Territory.

Professor Davies' statements had a baneful effect, because they taught false history. Instead of being an instantaneous production and the work of one man, the method of United States land surveying is the result of development, extending over several years of time, and has been built up the same as other systems of business.

Mansfield's services on the early surveys were invaluable, for it was he who reduced confusion to order and perfected the system. Nevertheless there were men before him who had originated that system, applied it to practice for seventeen years and had opened up a field wherein he might improve, but could not invent.

In the above-mentioned names there are three at least who are entitled to consideration. At the same time we could give credit to one or two others. Thomas Hutchins, Rufus Putnam and Jared

* Manuscript received March 23, 1904.—Secretary, Ass'n of Eng. Socs.

Mansfield, each in turn, conducted the early surveys, and the terms of their services cover a period of 27 years, during which the system was inaugurated, developed and brought to a final completion.

A detailed account of these men while engaged on this public service, their characteristics, acquirements and qualifications for the duties required of them, their management of the work and the manner in which it was executed, the part that each one contributed and how they acquitted themselves would form a very interesting chapter in American history.

What might be called a germ, which afterward grew to maturity, was a plan devised and submitted by Thomas Hutchins 12 years or so before the Revolution. In the famous Indian expedition commanded by Col. Henry Bouquet, Hutchins was a captain in one of the regiments and served as engineer officer. After the return to Philadelphia a report was printed, a part of which consisted of a scheme, submitted by Captain Hutchins to the Colonial Government, for the protection of settlers on the frontier against Indian hostilities. His plan, which was written out in detail and illustrated by a map, was this:

For a colony of 100 families, or 500 people, lay out a tract of land 1 mile square on some stream, and in the center build a stockaded fort. Divide the remaining land around the fort into streets and lots, 100 lots in all, of about $5\frac{1}{2}$ acres each, one lot for each family to build upon. Around the 4 sides lay out 8 more squares, each a mile in size, one of them to be reserved for woodland and the others to be divided into plantations or farms for the colonists, a farm for each family. In this plan Captain Hutchins used the word square. Repeat the operation and lay out another colony immediately adjoining or some miles distant, according to the necessity or circumstances. In this manner cover the whole frontier line with a row of forts and colonies.

This was the first suggestion ever made for dividing land into regular tracts 1 mile in size, and it has been considered by some to be the origin of the method long after adopted. What result this plan had on subsequent legislation, when the first land law was enacted, can never be known. It must have been widely read at the time, and in some manner might have been instrumental in the formation of the system of surveying our public domain.

The next step, or perhaps what might be called a first step in the origin of the method was this: In 1783, after the close of the war, but before the army was disbanded, a mass meeting of nearly 300 officers was held and a petition to Congress drawn up. The prime mover was Rufus Putnam, and probably he wrote the petition

which asked Congress to grant that all the lands they were to receive under the act of 1776 should be in one body and located between the Ohio River and Lake Erie. Putnam was charged with the duty of presenting the petition to Congress, which he did, through his friend Washington, to whom he wrote a long letter, in which he gave his reasons why the petition should be granted. In this letter General Putnam used the following language:

"The petitioners hope that no grant will be made, except by *townships 6 miles square,* or 6 by 12, or 6 by 18, to be divided by the proprietors to *6 miles square,* that being the standard on which they wish all calculations to be made."

Mark the word township. This is considered by many people who know the facts to be the origin of the method which was afterward put in practice. It was the first suggestion ever made, or the first plan ever proposed, of which there is any record, for dividing the lands of the Northwest Territory according to a method which two years later was enacted into a law. That Putnam was the author of the idea there can be no doubt. He had been a land surveyor the greater portion of his life, and must have known from experience the advantages of dividing land in that manner over the old metes and bounds practice that had long prevailed in the colonies.

It would be interesting to know why Putnam was so firmly committed to a 6-mile square township, for in his request for that standard he appears to be somewhat set in his opinion.

The surveyors of the Western Reserve, long after, considered a 5-mile square township to be the proper size, which they subdivided into quarters of 4000 acres each, with the expectation, perhaps, that a further division would be made into sixteenths of 1000 acres and possibly again into 500-acre tracts. This was a good land division, and a plan that would naturally have many supporters with those who gave thought to the subject. It was very simple and semidecimal in feature, but the subdivisions were too large.

It is a question whether the 5-mile township would not have been better than the one afterward adopted. Many modern surveyors would answer in the affirmative. It was about the correct size, and would have been a sort of amendment to Jefferson's first plan by which sections could have been grouped by hundreds.

But the township was necessary, whether it was 5 or 6 or 10 miles square, because the subsequent subdivisions into sections was a natural procedure. The mile was a standard measure or a unit of length, so the square mile became a unit of surface, which could be divided to fractions sufficiently large. A division by sections

alone would soon have become cumbersome, and a larger unit or measure like the township could not be avoided.

The method of public land surveys first assumed a definite and permanent form by congressional action in 1785. At that time the question of raising revenue was paramount, and the wild lands in the West were looked to for that purpose. A committee was appointed, of which Thomas Jefferson was chairman, to submit a plan for putting those lands upon the market. The report proposed, as a preliminary, to divide the territory into tracts 10 miles square, to be called "hundreds," and these, in turn, into 100 squares, a mile in size, to be called "lots." Jefferson's work is apparent in this scheme. The tracts were afterward reduced to 7 miles square, and again to 6 miles. After considering the whole subject for over a year Congress adopted the report as amended, and it became a law, which is known as the Ordinance of 1785.

This is the origin, by law, of the method of surveying the public lands of the United States and the first legislation on that subject. Nothing is known officially beyond this act and who the men were that influenced the legislation, and by what manner or means the result was accomplished will never be known. If we could reveal some unwritten history of about that date the name of Rufus Putnam might be conspicuous and perhaps Hutchins also, for they were both prominent men, of great ability, and possessed character and influence. Their advice would naturally be sought for and appreciated by those who framed the law.

In this act the words township and range appear for the first time. Lots were changed to sections and their numbering made as at present at a later date.

The Ordinance of 1785 provided for the following:

The division of territory into townships of 6 miles square.

Numbering of townships from south to north, beginning each range with No. 1, and ranges to be numbered by progressive numbers to the westward.

All lines to be marked on trees and described on plats.

A plat of each township to be made, "and all mines, salt springs, mill sites, salt licks, water courses, mountains and all other remarkable or permanent things over and near which such lines shall pass shall be marked on the plats, and also the quality of the soil."

Plats of townships shall be marked by subdivisions into lots of 1 mile square or 640 acres, and numbered from 1 to 36. In fractional townships the lots shall be numbered as if the township was entire.

External lines of townships to be marked at every mile with lot corners.

All lines to be run by the true meridian and the magnetic variation to be noted on all plats.

A tract of country west of the Pennsylvania line and south of the Connecticut Lands was directed to be surveyed in this manner, and work was commenced in the early summer of 1786.

The office of Geographer of the United States was created, who was to have personal charge of all surveys, and Thomas Hutchins was appointed to the position. He was the first and only incumbent of that office. One surveyor from each State was also appointed.

Hutchins' record while in charge of the work comprised the survey of that tract known as the Seven Ranges and a small portion of country between the Great Miami and Little Miami Rivers.

It was his good fortune to inaugurate a public work which in time grew to enormous proportions, and became of invaluable benefit to the people of this country, a work whose results will remain for all time. He deserves what credit is his, for he was an accomplished surveyor and had been a brave soldier. In his appointment the Continental Congress made a good selection.

A commencement was made at the south end of the Pennsylvania boundary, on the north bank of the Ohio River, and a line run 42 miles westward, which has always been known as the Geographer's Line. Afterward the country was run into ranges southward to the Ohio River, and then into townships by east and west lines, but it was several years before all subdivisions into lots were completed. Hutchins did not live to see the end of his work, but died while in harness. The surveys were then managed by the Treasury Department and for some years after the beginning of the present Government.

At this time the Indians assumed a hostile attitude, which soon led to a long and bloody war. Immigration came to a standstill and the public surveys also, but after Wayne's decisive victory and the treaty of Greenville, which brought a permanent peace, people began to look again for homes in the Northwest Territory, and what might be called a record era in land surveying commenced.

This was opened by the act or law of 1796, which provided among other things for the survey of all lands not already disposed of, changing the name of lots to sections and introducing the present method of numbering them, and creating the office of Surveyor-General, which was filled by the appointment of Rufus Putnam.

It is not within the province of this paper to give a detailed history of the surveys conducted by Putnam under this law. They

were soon commenced west of the Seven Ranges and also beyond the Great Miami River, but principally in the Military Bounty Tract, and were carried forward as fast as surveyors could perform the work or while there was money appropriated.

For some reason the townships in the Military Bounty Tract were made 5 miles square and subdivided into quarters. This small piece of country is the only instance where the general Government surveyed land in that manner.

About the time Putnam began operations, or a short time previously, surveys were commenced in the Western Reserve, under the general charge of Seth Pease, who was on the ground with a number of parties. The surveyor-in-chief began by running the 41st parallel westward as a south boundary to the Connecticut Lands; then commencing at the eastern end of the Reserve to lay out townships 5 miles square, he worked westward, but it was several years before all the land was divided.

When Surveyor Pease began to number ranges in the Western Reserve, from the Pennsylvania line to the west, and townships to the north from the 41st parallel, he did a very important thing without knowing it. He invented the system of principal meridians and base lines. The Pennsylvania line had been run 12 years before as a west boundary to that State. Pease ran the 41st parallel as a south boundary to the lands owned by Connecticut. They were known to him as boundary lines, yet he made them a principal meridian and base line, something which he could not avoid doing and what anyone else would have done.

Putnam numbered the ranges and townships of the Military Bounty Tract in the same manner. He made a principal meridian of the west line of the Seven Ranges and a base line of the south boundary to the tract. He did not know that he was bringing out an idea which his successor in office would elaborate on a very extensive scale.

If the scheme of establishing 2 main lines for the government of all surveys in an extensive tract of country was original with Mansfield, he certainly must have found its inception in the Ohio surveys when he became Surveyor-General.

General Putnam remained in charge of the Western surveys until the summer of 1803, when he was removed by President Jefferson, and what might be called the second chapter in the history of this work came to an end with his retirement from office.

How much credit should be given to Putnam for the origin of this method? Just about all of it. The pith of the whole system is the division of vacant territory into townships 6 miles square, and

Putnam was the author of that idea. All the other features are merely attachments. The main part of an invention is the principle. He who devises this is the inventor. Others always follow who make improvements, until the invention approaches completion. Whether Putnam completed the method in all its details or not, he first suggested the idea which became the principal part of the whole structure. This is his record on the upbuilding of that structure. If a history of the public land surveys is ever written, the name of Rufus Putnam should stand above all others.

At this period Jared Mansfield took charge of the work as the second Surveyor-General. Jefferson had become dissatisfied with Putnam's manner of conducting the surveys, and had sent Mansfield to rectify errors and introduce something more like scientific method. Putnam had claimed that the lines could be run by true meridian only with difficulty, and that it was as well to use a fixed variation, whether the lines were north and south or not. Jefferson was too educated a man to coincide with this opinion and demanded something superior. Herein is where his work and influence on the early surveys occur, and if he is to be credited with a share in planning the present system, it is in this demand for a better practice and his efforts to obtain it.

What did Mansfield do as a Surveyor-General? This is a difficult question to answer. If he ever told his Government of anything he had done, that report is not available. It is doubtful if there ever was another official of this Government of whose services so little is known. In the whole field of biographical literature the record is silent as to his individual share in building up this edifice. One is sometimes led to believe that it was Jefferson himself who first proposed the scheme of a framework consisting of a 2 astronomically measured lines, and that he sent Mansfield to execute his ideas. In our researches we are able to gather a few scraps of information, here and there, from which we learn very little, but can infer much. We are told in his son's "Personal Memoirs" that he established three principal meridians in Ohio and Indiana while he was Surveyor-General, but this undoubtedly is second-hand information. We know from a report of the Secretary of the Treasury how much money had been expended on public surveys in each Territory up to the end of 1812, the date when Mansfield resigned.

Furthermore, we are given an account of the work, so far as it had progressed to 1817, by some Western writer in "Niles' Register" of that year, but it does not separate Mansfield's work from that of his predecessors.

For the first two years Mansfield remained in Ohio, and con-

tinued the public surveys as they had previously been conducted. There was nothing else he could do, for it was too late to introduce much improvement. He probably ran the correctional meridian from the Ohio River north to the Military Bounty Lands, in order to close up the distorted surveys on the east and to commence correct ones on the west to the Scioto River. He must have ran the Ohio-Indiana boundary line, at least that part of it north of Fort Recovery, as a State line. This afterward became the first principal meridian, and was used for that purpose by Edward Tiffin, who followed as Surveyor-General.

If Mansfield did establish three principal meridians in Ohio and Indiana these lines must have been two of them.

In 1805 Mansfield went to Indiana with several surveyors, and here is where he displayed his scientific acquirements. He made a first commencement with that system of surveying which has been followed for 100 years and continued nearly to completion. He found in Indiana Territory a large tract of country where no one had worked before, entirely removed from the checkerboard work in Ohio, and he proceeded to put his own ideas into execution, with the present second meridian and its base line as a result.

Here is where Mansfield was superior to Putnam or Hutchins. But he had opportunities which they had never known, and was not hampered by the stipulations of any law. He had been given full rein, and let it be said to his credit that he made good use of the privilege. They had considered a tract of country to be a plane surface. Mansfield considered it a spherical surface, and knew that range lines running north would approach each other, with the 6-mile distance apart gradually growing less, which would in time require rectifying. This he did by devising a system of standard parallels or correction lines, which he called parallels to the equator.

Some time after this surveys were commenced on the third principal meridian and later on the Michigan meridian, and there is reason to believe from the writer in "Niles' Register" that he planned the fourth meridian and perhaps the fifth. When he resigned his office the system was complete. His methods have been followed ever since, and extended over the whole vast public domain to the shores of the Pacific.

This is Jared Mansfield's record on the public surveys of this country, and it is certainly a very creditable one.

ADDRESS.

By George T. Wickes, President of the Montana Society of Engineers.

[Read before the Society at its Fourteenth Annual Meeting, Helena, Montana, January 9, 1904.*]

Gentlemen of the Montana Society of Engineers:

Searching for a subject upon which to address you with the hope of interesting you, in way of some engineering proposition or work, has been fruitless. The local engineer's practice rarely yields subjects of interest, save only to those for whom the work is undertaken. I have therefore thought that perhaps I might entertain you for a brief time in giving a few reminiscences, which may have in their favor a little worth in giving an idea of the great changes that have come over the Western country in comparatively but few years.

My earliest far Western experience commeneed at Wyandotte, now Kansas City, Kansas, in the years 1862 and 1863.

Kansas City, it now seems to me, could not then have had a total population of over 3500—Wyandotte not half that. Leavenworth was then the metropolis of the "border," from which the freight teams departed in large trains, loaded for the West and for New Mexico. Leavenworth could not have had a population of over 5000. Kansas City *had* evidently seen better days, judging from the then vacant warehouses on the bank of the Missouri River.

Between Wyandotte and Kansas City was a rope ferry over the Kansas or Kaw River, and then a fine stretch of timber land, largely of handsome oaks, but at times not considered a safe place to travel through alone. This was practically on the "border" then, near to the edge of the "Great American Desert," as it was called in the geographies.

Beyond Wyandotte, west 40 miles, was a small settlement called Lawrence; then, a few miles farther, a still smaller congregation of stone houses at Topeka; then came Fort Riley; adjoining this a few saloons, with their usual adjuncts, at Junction City. This was the true "border," 125 miles west from the Missouri River.

Beyond Fort Riley, then the farthest western United States Government military post, and before reaching the Rocky Mountains, was a vast rolling plain, 500 miles wide, and, to the best of my recollection, with not a tree in the whole distance.

This country, however, was covered with a thick matting of

* Manuscript received April 5, 1904.—Secretary, Ass'n of Eng. Socs.

buffalo grass; a surprising thing, for it grew from a hard-baked surface soil, something like a concrete pavement of to-day. From this hard surface would be emitted a rumbling noise, like the roll of distant thunder, when herds of buffalo were on stampede over it.

There were vast herds of these buffalo, whose numbers I would not attempt to estimate, but I have looked over them, dotting the plains as far as I could see, with a field glass. One was also scarcely ever out of sight of antelope; and at night it would seem as if the infernal regions had opened wide and emptied a howling multitude around us, from the baying and yelping of wolves and coyotes. The presence of Indians was an uncertain matter. One never knew where they were. Perhaps for days there would not be a sign of an Indian in the country; then, all at once, and always in the most unexpected manner, they would seem to rise out of the earth all around; it would be a veritable rising out of the earth, for they would circle around inside the many deep canyons and come up, from all directions, as if they were coming out from holes in the ground.

Five hundred miles of such country did not seem, then, like any 500 that might be mentioned nowadays in any part of the globe. We have become so accustomed to great distances, and to fast travel over them, that it is impossible for the modern man to realize the sensation of starting for a 500-mile ride horseback, or by mule or bull train. Leaving the border and starting for the Rocky Mountains seemed like going out into some vast wilderness, like going into impenetrable darkness in a strange place. It seems impossible, now, that then, at Kansas City, you could find no one that could tell you anything more than rumor about the Kansas Trail, as it was called, which, by the way, was no trail at all.

It was known that John C. Fremont had crossed the country in this general region, and there was a vague rumor that, some years before the time of which I speak, a party of about 200 had gone west from Kansas City, but what had become of them no one could be found that knew.

As I recollect, Fremont left with the railroad people no data which would give any guidance over this country, or any information as to what difficulties might be met with, in surveying or passing over it.

It was *the* Indian country of the West; the "wild Indian" of romance, with the "Noble Red Man" feature left out.

At the time of which I speak there was a remnant of the Wyandotte Indian tribe between Kansas City and Lawrence, and, a little farther west, of the Pottawattamie nation. Some of these, though

really with but little Indian blood left in their veins, were well-to-do, apparently, and, after a fashion, industrious people; but most of them were far different.

While working between Wyandotte and Lawrence I had to stay frequently in the dwellings and settlements of some of these sure-enough Indians, eat the food cooked by the squaws and sleep on the ground or floor, under the only shelter to be had, with Indians rolled up in their blankets around me, giving a fair opportunity, one might judge, to become acquainted with them. The squaws had a peculiarly odoriferous grease that they delighted to use; and the bucks, though they had tobacco, mixed it with dry sumac leaves, which, until one became accustomed to it, seemed like inhaling the smoke of burning red pepper. There was a "Half-Moon," a "Mud-Eater" and a "Sarcoxie" among them, and some of the enterprising ones had a squaw to hoe the corn and get the firewood, and another to do the cooking.

The troublesome Indians were the Cheyennes, Arapahoes and Sioux, who harbored between Fort Riley and the Rocky Mountains, chiefly the two former tribes on the route of our survey. At this time also there were bands of lawless white men, robbers and murderers, always on the lookout for an opportunity to rob, which invariably meant to murder as well, and to apply quick vengeance upon some hated or dreaded individual when caught off guard.

There was also another element, that did not make much noise, that had a quiet business way about them, that helped the courts materially to rid the country from these desperadoes. The local sheriff had not infrequently to cut some fellow down from the end of a string, one end having been used as a cravat, the other attached to the limb of a tree, a jutting log of a house, or even a tall fence rail, in the absence of something more convenient.

This sort of thing ended about 1865 or 1866, when a member from one of these gangs turned against his former comrades and brought the body of one to the settlement, with the story of a hard fight for his life, for the purpose of proving himself not one of the gang. Also, as the railroad progressed and Eastern people began to realize that it was possible for a continental road to be completed uniting the two oceans, immigration began more rapidly to come into the country, of such a stamp as made it less possible for the shrewd lawyers of the day to prove the very questionable alibis for their desperado clients, a game at which they had been so successful. These were the best paying clients of the time. Also, I think, it became unhealthy, as a business proposition for *themselves*, to accept such clientage.

Walking the streets with a large dragoon Colt's belted on the outside of one's coat was so common, that it was unremarkable; and when out on surveys my armament, for instance, was 2 of these Colt's revolvers in the holsters of the saddle, 2 in the boots or on the hips, with a Spencer or Henry rifle (that had come into use since the commencement of the Civil War) over the horn of the saddle. It was apt to be a question of life or death, whether or not a goodly number of shots were immediately ready for use.

Thinking of the times, the surroundings, the customs and daily incidents, it is with hesitation that I write or speak of them, for fear of being thought a romancer; and, when I look about me, and think of the intervening time, I am apt to imagine that the earlier experiences were dreams; but this notion is soon dispelled when some particular incident comes to my mind that makes such a notion impossible. They are mentioned now only to show what marked changes have taken place. The "border," in 1863, was more than 1000 miles east from here. Now there is no "border," save Nome or Bering Strait.

I rarely hear Denver mentioned that my thoughts do not go back to the Denver of the early time, when going in with the preliminary surveys of the Union Pacific Railroad, eastern division, as it was called. This was in 1865; Evans was Governor of the Territory; the whole of Denver then consisted of but 2 streets, Laramie and Blake, and they were but 2 or 3 blocks long.

There were always outfits camped around the settlement, and the streets were filled with miners, plainsmen, Mexicans and the roving roughs that infested the country. I remember passing one of the big gambling houses, either "the Diana" or "the Progress," and seeing a man brought out dead, who had been either shot or killed with a knife. The only ones who seemed to take any interest in the incident were the men who carried the body out, and they, it seemed, merely wished to remove an encumbrance from under their feet; for I went into the house, and all of the many tables were running, with all variety of games, crowds of men around each, many of the toughest looking characters that imagination can picture, and no notice was taken of that one of their number who was being carried out from one of these tables.

You can imagine what it was to bring a survey party of so large a number, all of the true Western type of those days, into a town such as Denver. I suppose that they thought they might take it for their own use for a time; the intrusion was in such a mass (and I know that some of them were of the wildest of the Western breed) that the soldiers from the post, that had been recently established,

came out, to try to bring the place to at least its normal condition. The officer of the day called upon me, and I found that he had a large number locked up, and concluded with him that it might be well to leave them housed until morning. In the morning, after rounding them into camp, another feature of the times commenced to be enacted. It was an election day; vehicles of all kinds and descriptions, from broken-down hacks to prairie schooners, began to arrive, with kegs, etc., in front, and the men were asked to take a ride. It was an especial occasion for a frolic, nothing more; the fellow who gave the most treats was the successful candidate, and it appeared perfectly legitimate that a vote should be cast each time a treat was given, no matter how many times the process had been repeated. Without doubt, the men voted for each candidate at least once, if not several times.

In connection with this, I am reminded of another, though a different kind of experience, still, one that belongs only to those days; but if it could be enacted now, as then, a show like Buffalo Bill's would require nothing else to draw a crowd.

When my survey had reached about 50 miles west from Fort Riley, a party of railroad officials, army officers and their friends came out to my camp from the post for a buffalo hunt. There were about 30 in the party; they were supplied at the fort with good horses, fine enough and fast enough, but not accustomed to see or smell buffalo. But, as buffalo were in great abundance, the fun commenced at once on their arrival. The uninitiated horses would enter into the spirit of the chase after a bull, cow or calf with as much spirit as the wild rider, but so soon as they came near enough to the unusual object and got a sniff of this plains habitant, their course, which had been like a hurricane in the direction of the buffalo, was immediately switched upon a tangent at right angles to the one they had been going; and a kodak would have shown the rider in the air, with arms and legs spread in all directions, but mostly in that of a whirling dip needle. Then a few would stop just long enough to be assured that the victim really had his legs, head and arms together, and could navigate, and on they would go again. It was quite as safe in camp as near one of these riders. The buffalo was in the safest position of all, while the horse was in the greatest danger; for, in one instance, a rider brought his gun down to blaze away at a buffalo in front of him and the bullet went below and between the horse's ears; result, the rider only continued after the buffalo until he came in contact with the unexpected earth. I am happy to say the party all returned to the fort, outside of boxes.

At the time of my arrival in Wyandotte there were two projected lines for Pacific railroads, both subsidized by the Government; one was planned to go west upon the Platte River Valley, starting at Omaha. The franchise for this was then held by Mr. Durant, of New York. The other was to leave the Missouri River at Kansas City or Wyandotte, going west through Kansas. This franchise was originally held by John C. Fremont. Afterward it was transferred by him to Mr. Samuel Hallett, a New York Wall Street broker. Mr. Hallett at that time had rails laid on about 10 miles of road west from Wyandotte.

This was during the Civil War. Men were very difficult to secure to prosecute the work, so that progress in the start was very slow; and I am quite sure that money, for building a road across what was then considered a desert, was also very hard to obtain. It was a scheme that seemed, to most people at the East, of the wildest nature, and most likely never to be accomplished. I remember that we, who were making the surveys, used to speculate as to whether we or our grandchildren ever would see a road that would reach the Pacific Ocean. After seeing the Rocky Mountains at Denver and the Snowy Range, and supposing that these were a fair sample of the whole, it appeared very improbable.

Mr. Hallett built perhaps 15 or 20 miles, when some trouble arose between him and one of the engineers, in regard to a report which Mr. Hallett wished made, and which was thought by the engineer to involve a misstatement of facts. Mr. Hallett abused the engineer, who, in return, shot and almost instantly killed him. This created but little excitement, and in a few days was apparently forgotten. The engineer afterward gave himself up, stood his trial and was acquitted.

Before his death Hallett had interested John D. Perry, and with him Adolphus Meyer, Carlos S. Greeley, Thos. L. Price and Mr. Archer, with some others of St. Louis, in his enterprise. After Mr. Hallett's death, Mr. Perry sent Mr. Bartholow to Wyandotte, who, for a time, had charge of the railroad construction.

Under the latter, having been a rodman for Mr. Hallett, I was continued as such on the line between Wyandotte and Lawrence. I do not remember the exact time when a more responsible position was given me, but I do recall locating the line from Leavenworth to Lawrence, then, beginning near Topeka, and carrying the preliminary surveys through to the mountains, and after, the final location of a portion.

Until the road was completed to the neighborhood of Topeka work progressed very slowly. Then the St. Louis men, and interested

parties in Cincinnati, under the leadership of R. M. Schoemaker of that place, formed a unique company somewhat on this fashion: They divided themselves into 2 parties; 1 consisting of the President and the Directors, the other of the builders, under R. M. Schoemaker as chief engineer and manager. This arrangement worked out very satisfactorily to all concerned. Contracting with themselves was an admirable scheme, and the work was rushed vigorously. I will not trifle with you by saying that our orders were to avoid going through any ant hills, but we *were* to avoid any others if we could get around them. This, though, was before 20° or even 9° curves were considered practicable. Long tangents, though, were not in it. Miles of road were what was wanted; but the country was such that we could get a good alignment on easy grades and with very light work. The Government subsidy of $16,000 per mile, the land grant, and then the privilege of issuing other securities in the way of bonds and stock, made probably a rich harvest for those interested. After all, if this harvest of cash had not been plentiful in the start, who knows what difference it might make now. There is plenty of room for conjecture as to what might have been.

The grading, tie-making and other kindred work was done by men brought from Canada, Americans suited for such service being in the army. These importations were sent out on the line with guns as well as with shovels and picks. If a party of a half-dozen or more Indians made a dash toward them I have known 75 or 100 graders to fling down their guns, with their shovels and picks, and rush pellmell for their adobe houses. Drawing guns to stop them was of no use. In the start, and before they realized what we were up to, the Indians would make these dashes for the fun of seeing these fellows run, and a *possible* scalp. They would turn very quickly if a few subcontractors or engineers started after them horseback. Such chases were apt to be exciting, particularly if one of the pursuers got separated from his friends unawares. The Indians would quickly see this, and would then circle around in a gulch to corral this lone individual; then *he* would have to lie down on his horse and stick the spurs in. Good horses were important at such a time.

The general course of the survey was that of the Smoky Hill River; divides had to be followed, to avoid the deep canyons washed out through the great depth of easily washed surface. The *immediate* surface crust was hard, and would shed water like a roof; but when this water began to gather together into channels, with ever-increasing numbers of streams added, they became mighty floods, that would tear down these gulches as if they would cut through to

the under side of everything; there were great areas for these floods to gather in; now, with the land cultivated, so that rain may be absorbed, such floods are probably rare.

Following the high lands with the road for a long time, getting water was a serious problem; at first, the low places were selected in which to dig wells, but this was unsuccessful. Afterward wells were tried at or near the divide, and water was found at reasonable depth.

We followed these uplands until some of the head waters of the Arkansas and Platte Rivers were reached, and then followed down the Platte branches to Denver.

I recall particularly, and with great vividness, when about at the head of the Smoky Hill River, the first appearance of snow-capped Pike's Peak; it could be compared to nothing so appropriately as to a wonderful emerald. It truly had as great varying color, with a radiance, a radiating beauty, that to me no emerald ever equaled. This magnificent appearance of a stone, with its incomparable luster, was set in a brown plain between it and us; and to the horizon, north and south, all irregularities were lost in the distance. The effect was marvelously beautiful. The mirage, common to the plain, gave a shimmer to the radiant coloring not seen with the real stone.

Our outfits for these surveys had to be very complete, having to provide for necessaries that would cover our wants for 6 months' absence from sources of supply.

Our teams, wagons and tents were obtained from the Government and paid for by the railroad company. I had an order, from Government headquarters at Washington, that any requisition I might make upon any post for supplies, in case of necessity, should be honored.

I have said that Fort Riley was the farthest western post, and so, in a sense, it was, so far as our general route was concerned; but there was a small post on the Arkansas River, 40 or 60 miles south from the course of our survey, called Fort Zarah. I think it was started as an emergency post for supplies, but recently made, and soon abandoned, for I never heard of it after. I had its location given to me, as nearly as possible, and when I supposed we were in its vicinity, concluded, as a matter of safety, to add to certain of our supplies; I therefore took the ambulance, granted to me as engineer in charge, with 4 fast mules and a driver, and started to find the post, traveling somewhat as one does at sea, with a compass. Outside of the painfully disagreeable experience of sleeping for a few hours in a place much inhabited, little of moment occurred to

impress me, save that, while returning at night, that there might be less chance of Indian attack, we had an experience in the way of seeing a herd of buffalo on full stampede. It occurred about midnight. Above the noise of the ambulance I heard the unmistakable rumble and roll of the distant herd. Swinging the leading mules and fastening them to the rear of the ambulance was all that could be done, save to wait. How long this was I cannot say. I could see the black line quite a distance from us, but could tell nothing of the course of the herd, which passed close in front of us, so close that the forms of the bulls on the flank were distinct in every particular. If I were an artist, it seems to me now, I could draw those forms, every line. There were no remarks between the driver and myself, as I recollect, but, after the living avalanche had passed, there *was* a long-drawn sigh of relief. I do not now recall the least other incident, not even arriving at camp, but that rush of the buffalo herd is indelibly impressed upon my memory. A herd of buffalo on stampede is a blind, merciless, overwhelming mass, that annihilates anything destructible within its course. It would destroy a part of itself, if, by any chance, some of its number should fall. Each bull, when stampeding, is a great senseless machine, seeing nothing but its immediate leader, which he follows, with his immense head close to the ground. The rush is by instinct rather than by sight. The objective point is to be reached, no matter what may be in the way. Such herds are led by the largest, strongest bulls. They are flanked by bulls and their rear is brought up by others. I have watched them feeding as well as on stampede. When pasturing they are like an army, with outposts, having 3 bulls as sentinels on every prominent point surrounding the herd; but, on stampede, they have lost all save the sense to rush in close mass in a certain direction, swerving for nothing.

We absolutely lived upon buffalo meat; it was almost bread and meat. To be sure, we had quick-made bread, but that did not count. My recollection goes back to the *perfect* satisfaction of sitting down on the ground with a *stack*, a tin plate *heaped* with nicely fried hump or tenderloin before me, which was none too much to satisfy the appetite, with a quart or two of coffee sweetened with brown sugar.

This was before the tin-can age. We once tried what the men called "desecrated vegetables." These were a desiccated, dried up, apparently hydraulic pressed mass of old cabbage mostly, and any other old thing mixed; but it had one quality that surpasses belief, the way it would swell when put to soak. I think one cake would expand to the bulk of a fair horse feed. When cooked, it was about

as good as eating toothpicks. We gave it up. Our regular meals were at daylight in the morning and just before dark at night, and we carried in our pockets jerked buffalo meat, which we ate, when inclined, during the day, while walking or riding.

This "jerked" buffalo meat is worthy of especial note. All of ours was made from the "hump" and "tenderloin" of the bull. It was cut into strips, about 1¼ inches thick, about 3 inches wide and say a foot long; then it was threaded upon small rope, which was wound around our wagon bodies and bows. Sometimes a wagon would be literally covered with such a fringe. At first a thin, but very strong cuticle would form, which would strengthen and thicken in time, to say about the thickness of blotting paper. Cutting a piece of this meat across the grain, to eat, the inside, unless it was very old, would be found soft, with none of its flavor gone. Even when very old, if properly prepared, it was the delicious meat it was before it had gone through this process of curing.

Conditions now are unquestionably changed, so that it is doubtful whether the same results could be obtained, as there is unquestionably more moisture in the atmosphere now than there was then, and I have no recollection of flies in those days on the plains. Flies, like some other things, have come with civilization, to lay their unwholesome eggs to hatch destructive agents.

Our only fuel was "buffalo chips," and an admirable fuel it was. It seems to me that food, cooked over a fire made from these, had an appetizing flavor that ordinary wood cannot give. I believe no "plainsman" will deny this.

What marvelous changes have occurred wherever one may look! Where I was thankful to have a tent to keep the wolves out, and a sufficient force of men to save our scalps, are now railroads by the thousands of miles; cities, with opera houses, fine hotels and elegant homes; wonderful improvements, inventions and discoveries that have altered conditions of everything that has to do with our daily existence and advancement. To be sure, unwholesome weeds have started to grow, as in the best of cultivated crops. We must make an earnest effort to eradicate these, or our harvest of good things will quickly begin to grow smaller. Only eternal vigilance and unbounded energy can suppress such pernicious growth. But I have unbounded faith in the strength and rightmindedness of our American people, in every walk in life. The aims of the masses are true and elevating; the comparatively few are barnacles and poisonous; and it is my conviction that, though the changes of the past have been great, those to come will be still greater and grander! May you, my friends, participate in the gathering in of these harvests.

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A DESCRIPTION OF SEWAGE DISPOSAL SYSTEMS IN MASSACHUSETTS.

BY X. HENRY GOODNOUGH, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, November 19, 1902.*]

THE modern sewerage system, like many other public services, has been evolved from very crude beginnings.

The first sewers in the State were built in the city of Boston probably more than 200 years ago. These sewers were evidently, for the most part, drains for removing soil or storm water and sink drainage, and were built and owned by private individuals or associations of citizens living on a single street or in a small district. About the year 1823 the city took control of the sewers, but for several years after that time fecal matter was rigidly excluded from them. In 1857 there were 6500 water-closets connected with sewers in Boston, and in 1885 about 100,000. The history of sewerage in the other large cities and towns in the State is probably similar to that in Boston. Sewers were at first chiefly drains for the draining of streets or wet places, the removal of standing water and the drainage of cellars, and the principal sewage they received came from sinks.

After the introduction of public water supplies in the cities and towns sewers came into more general use, and their proper construction and management became of importance. Twenty years ago, however, there were still only about twenty cities and towns in this State which were provided with sewerage systems. At the present time ninety-four cities and towns in the State have fairly complete systems of sewerage.

* Manuscript received March 21, 1904.—Secretary, Ass'n of Eng. Socs.

The method of disposing of sewage in all cases was to discharge it into the nearest body of water—whether river, pond or harbor—and little heed was given to the conditions existing about the outlet. As the quantity of sewage discharged at these outlets increased they came to be commonly very serious nuisances.

About thirty years ago the advantages of keeping sewage separate from storm water were recognized, and at the present time the combined system of sewerage is very rarely used in this State in the construction of new systems. On account of the necessity for purifying sewage the combined systems in some cities and towns are being reconstructed in order to separate the sewage from the storm water.

Where sewage is discharged into a large river or into the sea, well away from the shore, in such a manner that it becomes thoroughly diluted before returning to the shores, danger of nuisance may be avoided, and many cities and towns situated on the seacoast or along the larger rivers effect a satisfactory disposal of their sewage in this way.

The sewage of the Metropolitan district, for example, is efficiently disposed of at Deer Island and Moon Island into tidal currents, and fouling of the shores is avoided. At Moon Island the sewage is stored in reservoirs and discharged on the outgoing tide in such a manner that it does not come back on the returning tide. At Deer Island the 50,000,000 gallons of sewage per day brought down by the sewer are discharged continuously into a strong tidal current, and, whether the tide is rising or falling, this sewage is disposed of effectually within the space of a square mile and does not affect any inhabited shore.

In some of the inland cities and towns situated on the larger rivers sewage is efficiently disposed of by direct discharge into the river. Serious local nuisances exist, however, at many of the sewer outlets into streams at the present time owing to their faulty location or construction. These outlets are usually placed at the bank of the stream at the edge of high water, where danger of injury from freshets is likely to be avoided, and at times of low water in the river in the summer season, or when the water is held back by dams during the night or on Sundays or holidays, very serious nuisances are created by the collection of sewage upon the exposed bottom of the stream.

The objectionable conditions caused by such outlets can be prevented by carrying the outlet a sufficient distance into the stream, so that the sewage becomes thoroughly mingled with the water before it can return to the bank.

When combined systems exist it is not essential that all of the sewage and storm water be carried out into the stream, and experience has shown that, if the dry-weather flow is carried to some point of discharge well away from the bank of the stream, the mingled sewage and storm water may be allowed to overflow at the edge of the stream without creating objectionable conditions.

Successful outlets of this sort are in operation at Springfield, where at several of the sewer outlets a pipe of sufficient size for the removal of the dry-weather flow of sewage is carried from the sewer a short distance back from the outlet out under the river bed to a distance of 200 to 300 feet from shore, so that sewage is rarely visible in the neighborhood of the outlet and the fouling of the banks is avoided. At times of rain the mingled sewage and storm water discharges through an overflow at the edge of the river bank, but the quantity of sewage discharged in this way is very small compared with the total flow and no nuisance is created.

The most serious nuisances, however, resulting from the discharge of sewage into streams and inland waters are those resulting from the discharge of so large a quantity of sewage in proportion to the flow of the stream that the river is rendered filthy and offensive for a long distance below the outlet.

The effect of the discharge of large quantities of sewage into the small streams had frequently been illustrated as early as 1885, and in 1887 the experiments of the State Board of Health, with the special object of studying methods of purifying sewage and preventing the pollution of streams, were begun at the Experiment Station at Lawrence.

At the time these experiments were begun, fifteen years ago, very little was known anywhere with regard to methods of purification of sewage. Sewage farms were in existence in England and on the Continent of Europe, but the method of disposal was, in most cases, that of irrigation, and the quantity that had actually been disposed of had reached perhaps 10,000 gallons per acre per day.

The earlier results of the experiments showed very conclusively that sewage could be purified efficiently by filtration through sand or gravel, at rates depending to a considerable extent on the character of the material, but, with ordinary sands and gravels found in our valleys, at rates ranging from 40,000 to 80,000 gallons per acre per day.

In 1889 the first system for the purification of sewage by intermittent filtration upon any considerable scale in this State was constructed at Framingham, upon lines indicated by the Lawrence experiments, and was followed two years later by systems at

Gardner and Marlborough, which have been in successful operation since that time.

The total number of cities and towns now provided with sewerage systems in the State is about ninety-four, of which about one-fourth dispose of their sewage by some system of purification; thirty-five discharge into the sea and the remainder into inland streams.

While the results of investigations at the Lawrence Experiment Station early showed the feasibility of purifying large quantities of sewage by filtration through sands and gravels, found commonly in the valleys of the State, investigation was early directed to the practicability of purifying sewage at more rapid rates than it was found possible to maintain with the ordinary sand filter.

The organic matter in suspension in sewage has been the chief source of difficulty in its purification, on account of the clogging of the surfaces of filter beds, and most of the investigations upon rapid methods of purification of sewage have dealt with processes of getting rid of this organic matter in some manner—by straining or precipitation or reducing it to simpler forms.

By passing sewage through a settling tank and allowing from two to four hours for sedimentation it has been found that about 30 per cent. of the organic matter can be removed, but the sludge has still, of course, to be disposed of. By chemical precipitation about half the organic matter in the sewage can be removed, but, in addition to the cost of chemicals, the sludge problem still remains. Both of these methods are, however, used to advantage in some cases.

It was discovered early in the investigations that a rapid change takes place in sewage after the mixture of the waste waters and the discharges from the fixtures in dwelling houses, stores and offices first takes place in the sewers.

Much clean water finds its way into sewers by waste from fixtures in houses and by leakage through defective joints and cracks in the sewers and tributary house drains; and fresh sewage may contain dissolved oxygen, but the oxygen is subsequently used up and the organic matters in the sewage become broken up and finely divided, and after remaining for a considerable time in the sewers, or passing through a tank or reservoir, the character of the sewage is greatly changed.

About seven years ago the results of experiments made in England upon the effect of storing sewage in a tank for a period of about twenty-four hours were first published, showing that by allowing sewage to pass continuously and very slowly through a

closed tank the organic matters became broken up, decomposition and putrefaction set in, and a reduction took place in the quantity of organic matter. Much gas was evolved in this process and apparently very little sludge or sediment accumulated in the tank. This process of treating the sewage, so as to avoid the problem of dealing with large quantities of sludge, is known as the septic tank process.

At about the same time came the discovery of the contact filter. This, as usually constructed, is a filter containing coarse material, with an outlet controlled by gates. It is operated by filling it with sewage in frequent applications during a period of several hours, and subsequently, after allowing it to stand full, by draining it off. By first passing sewage through a septic tank and subsequently through contact filters, rates of filtration were maintained for a time far higher than with sand filtration.

More recently still has come the intermittent continuous filter—a filter composed of coarse material, to which sewage is applied in comparatively small and frequent doses, and allowed to run freely through the filter and out at the outlet.

Careful experiments have been made at the Lawrence Experiment Station for several years upon the operation of all of these processes of sewage purification, and very interesting results have been obtained.

It is not my intention to discuss the septic tank or the contact or intermittent continuous filters, since none of these methods of sewage purification is employed upon a large scale in Massachusetts.

It may be said, however, that the experiments which have thus far been made in the use of the septic tank with some sewages bring the sewage into such a condition that it is extremely difficult to purify it by any subsequent process. Moreover, sewage stored in a septic tank has generally an extremely foul odor as compared with ordinary sewage. It has also been found that sludge accumulates in septic tanks, and that it is necessary to remove this sludge at longer or shorter intervals.

Experiments with contact beds have shown that it is difficult to secure material with sufficient open space which will resist breaking down, and that there is a tendency in such beds for the open space to become clogged, reducing the capacity of the filters, a very serious matter if it reaches such a point as to make it necessary to renew the material.

The results of experiments upon the operation of intermittent continuous filters are very interesting, but there has as yet been very little opportunity for experience in the operation of experi-

mental filters of this kind. These studies are of the greatest interest and importance, on account of the necessity of finding some suitable means of purifying sewage in places where sand and gravel areas are not readily available. In Massachusetts, however, lands containing sandy or gravelly soil are found commonly in our valleys, and the cost of disposing of the sewage by intermittent filtration where such lands are readily available is, in general, less than by any of the processes thus far developed, and a more thoroughly purified effluent can be obtained by sand filtration than has thus far been found practicable by any of the processes indicated.

FRAMINGHAM.

Population in 1900.................................11,302

As already stated, the first sewage disposal system of importance constructed in Massachusetts for the purification of sewage was that at Framingham. This town is situated partially within the watershed from which the supply of Boston was drawn at the time the works were built, and a portion of the cost of the works was defrayed by the city, on the consideration that the disposal works should be located outside of the watersheds from which the city's water supply was drawn.

The sewage is collected by means of a system of separate sewers, discharging into a collecting or storage reservoir, about half a mile from the village; thence the sewage is pumped a little over two miles to the filtration area.

About 100 acres of land were purchased as a sewage disposal area, and upon this area about 20 acres of filter beds were prepared by leveling the land and taking off the loam and a portion of the subsoil to form embankments between the filter beds. The subsoil remaining on the surface of most of these beds is quite fine—much finer than in most of the other filtration areas in the State. Beneath the subsoil coarse gravel is found for a depth of several feet. Two main underdrains were laid beneath some of the beds which discharge the small amount of effluent which they collect upon the ground outside of the beds, where it is again filtered for the most part before entering Bannister Brook, which receives the effluent. The sewage is applied to these filters at an average rate of about 700,000 gallons per day, or 35,000 gallons per acre per day. The sewage is very strong, and is at times highly colored by manufacturing waste. The beds dispose of all of the sewage, and no unpurified sewage is discharged into the streams.

For several years corn has been grown upon these filter beds.

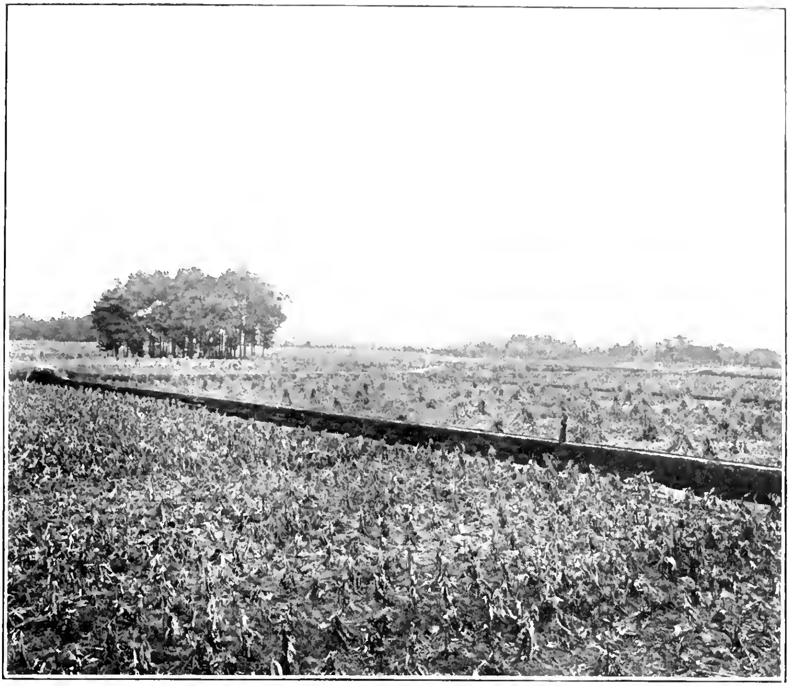


Fig. 1. Framingham. View Showing Filter Beds at Time of Harvesting Crop of Corn.

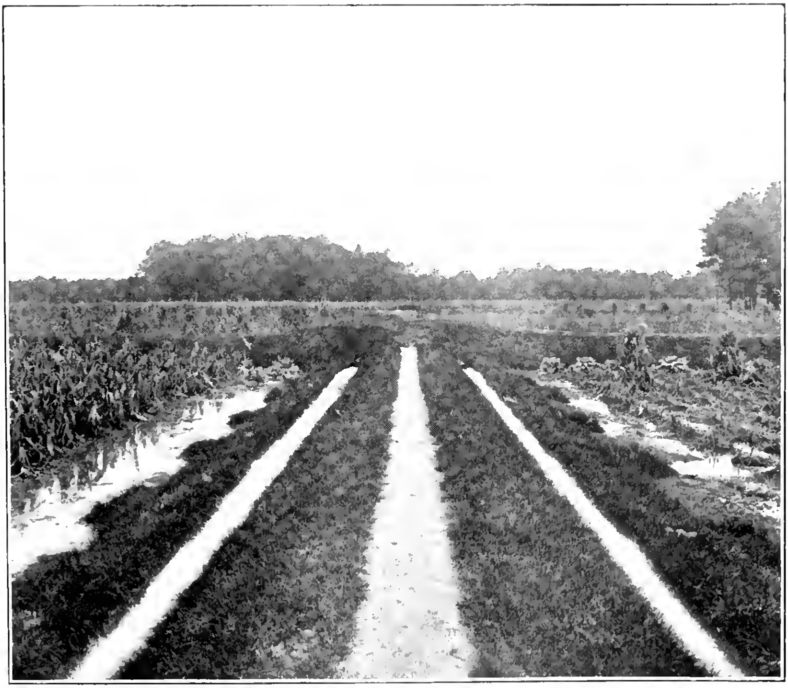


Fig. 2. Framingham. One Method of Distributing Sewage on Filter Beds.

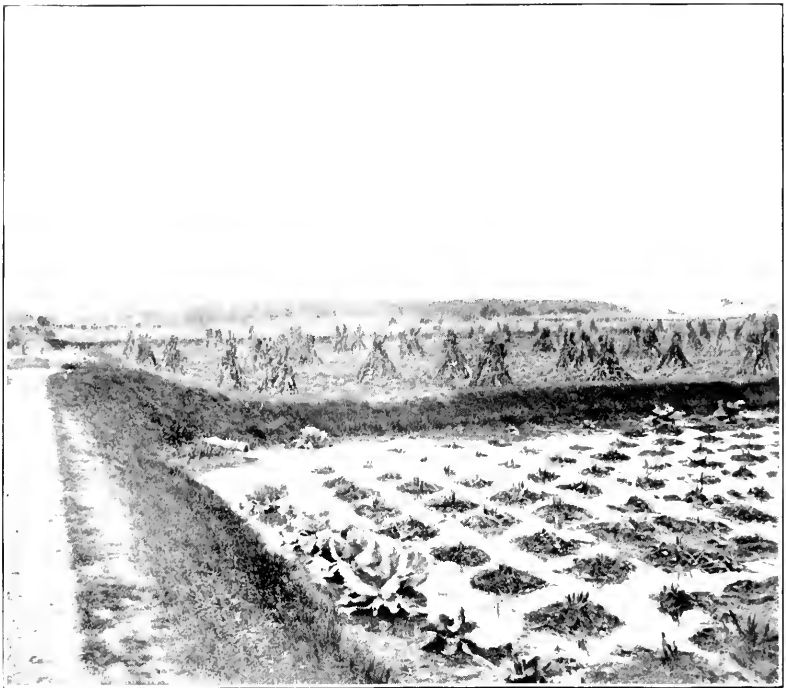
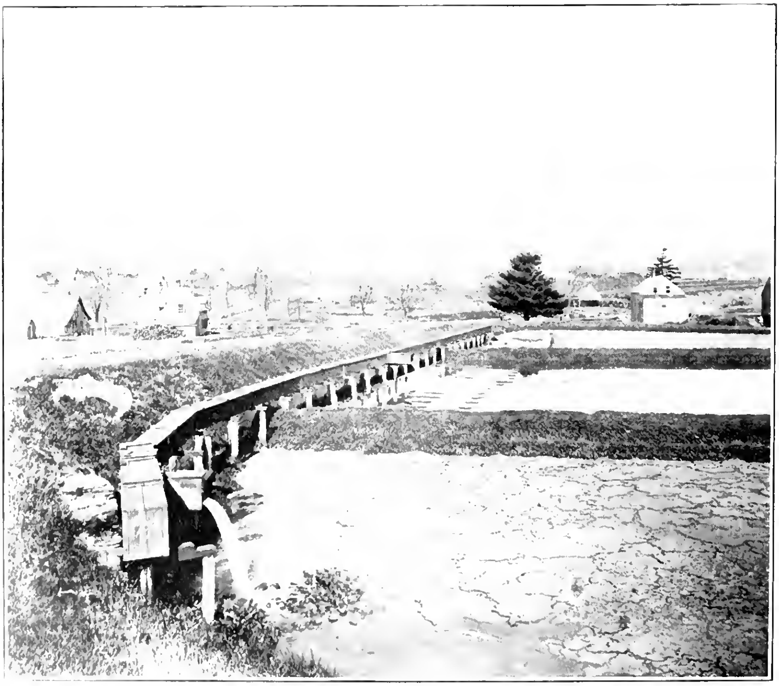


Fig. 3. Framingham. Another Method of Distributing Sewage on Filter Beds. The Surfaces of the Filter Beds Remain in the Condition Shown During the Winter, the Ice and Snow Resting on the Corn Hills.



4. Gardner. View of Filter Beds, Showing the Accumulation of Solid Matter on the Surfaces.

The corn crop is sold at auction early in the fall, and the purchasers are required to cut and remove the stalks. After the removal of the crop nothing further is done to the land until the following spring, when it is plowed and again prepared for planting. All of the sewage, including the sludge, is discharged upon the filters, and no accumulations upon the surface of the filter beds are removed except at times in the spring.

GARDNER.

Population in 1900 10,813

A sewerage system in the central portion of the town was constructed in 1890, the sewage being conveyed to a filtration area in the valley of Pond Brook, south of the village. Subsequently, a sewerage system was constructed in the westerly portion of the town and the sewage conveyed to a new purification works situated in the town of Templeton, south of the Otter River. All of the sewers are built upon the separate plan, but considerable storm and ground water find their way into the sewers.

The average quantity of sewage delivered to the older filtration area amounts to about 400,000 gallons per day, increasing in wet weather to 800,000 gallons per day. All of the sewage is conveyed to the filtration area by gravity. The total area purchased was 19.4 acres, and the total area of filter beds thus far constructed 2.7 acres, most of which are very thoroughly underdrained. The sewage is received in a settling tank, from which it flows to the different filters, the sludge being disposed of upon sludge beds, where it is allowed to dry and subsequently removed, some of it being used as a fertilizer. The beds are not of sufficient capacity for the purification of all of the sewage during periods of high flow, especially in the spring, and much sewage is discharged unpurified into Pond Brook.

The new system for West Gardner is also constructed upon the separate plan, and in this system also the flow of sewage is increased greatly at times by leakage and by storm water which find their way into the sewers. The sewage is conveyed by gravity to the filtration area, where it is first passed through coke strainers and subsequently applied to sand filters, nine in number, having an aggregate area of 2.25 acres, which are thoroughly underdrained. The quantity of sewage amounts on an average to about 300,000 gallons per day. A portion of the solid matter is removed from the sewage by the coke strainers and is deposited nearby, much of it being used subsequently as a fertilizer. There are four strainers, having a combined area of one-fourth of an acre.

MARLBOROUGH.

Population in 1900 13,609

The sewers are constructed upon the separate plan, but much leakage and storm water finds its way into them, enormously increasing the flow at certain seasons of the year. The average quantity of sewage amounts to about 1,000,000 gallons per day, while the maximum quantity is probably as much as 4,000,000 gallons per day. The sewage is conveyed by gravity to the filtration area, located about 4 miles from the central portion of the city. Forty-nine acres were purchased by the city, upon which twenty filter beds and six sludge beds, having an aggregate area of 11.7 acres, have been prepared for the purification of the sewage, all of which are thoroughly underdrained. Sewage is received in a settling tank, in which a portion of the solid matter is removed, the sludge being discharged upon sludge beds and subsequently removed and used as a fertilizer upon lands in the neighborhood. A portion of the sewage is discharged untreated in times of wet weather, especially in the spring, into a neighboring brook.

CLINTON.

Population in 1900.................................. 13,667

The sewers are built upon the separate plan, but some storm water finds its way into them, and there is much leakage into the sewers in the wetter portion of the year. The average flow is about 625,000 gallons per day, but in wet weather it is as high as 1,600,000 gallons per day. The sewage is delivered to a pumping station, where it is received in a reservoir intended to hold the night flow, from which it is pumped in the daytime to filter beds in the town of Lancaster.

The total area of filter beds is 22.5 acres, divided into twenty-five beds. The soil is very coarse and porous, and the level of the ground water was originally many feet below the surface of the beds, so that a limited amount of underdrainage has been found sufficient for the removal of the effluent.

At periods of very high flow sewage is sometimes wasted into the river at the pumping station, but otherwise all of the sewage, including the sludge, is discharged upon the filtration area, the effluent from which flows into a small stream tributary to the Nashua River.

BROCKTON.

Population in 1900.................................. 40,063

The sewers are constructed upon the separate plan, but the flow is considerably increased by leakage in the wetter portion of the

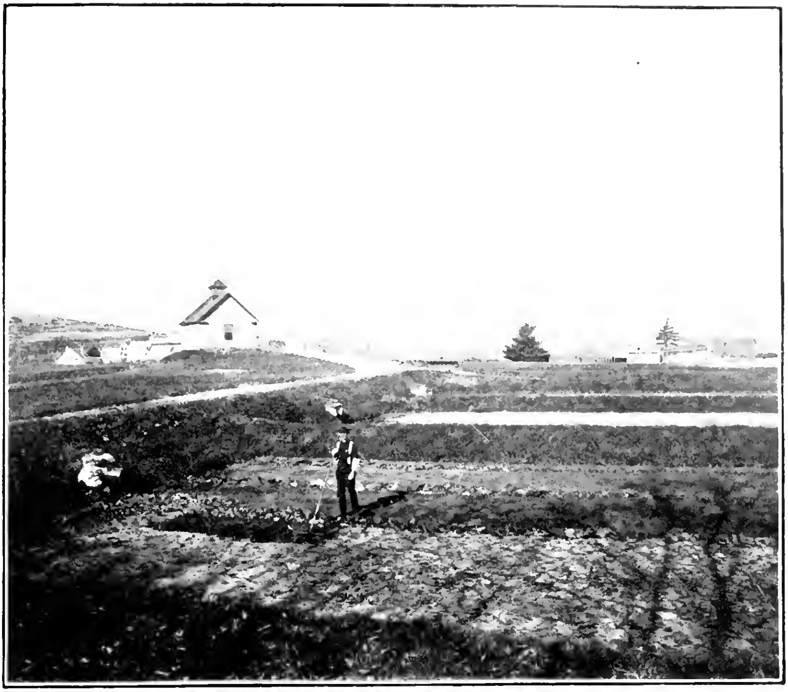


Fig. 5. Gardner. Cleaning a Filter Bed.

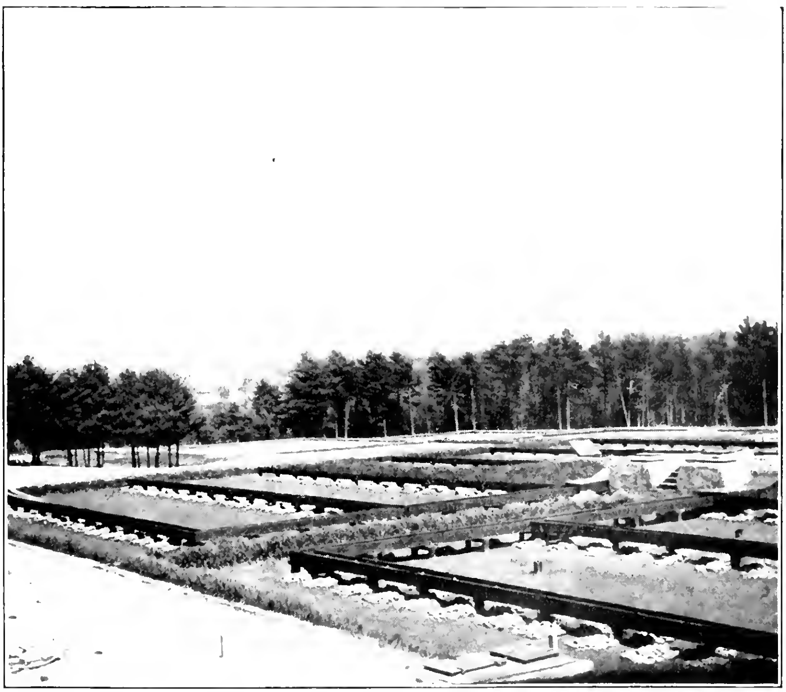


Fig. 6. Gardner. View of Coke Strainers, Showing also Sand Filter Beds in the Distance.

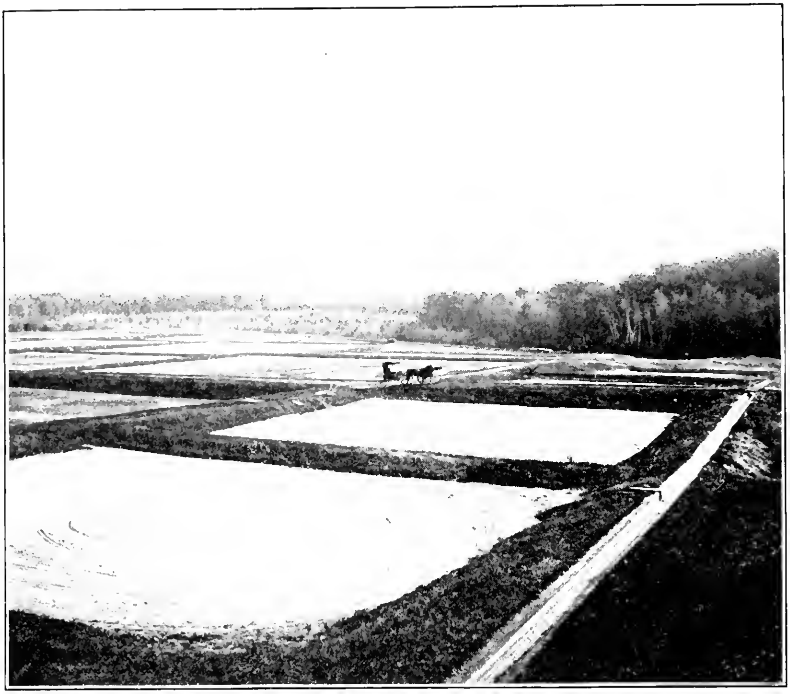


FIG. 7. MARLBOROUGH. GENERAL VIEW OF FILTER BEDS.

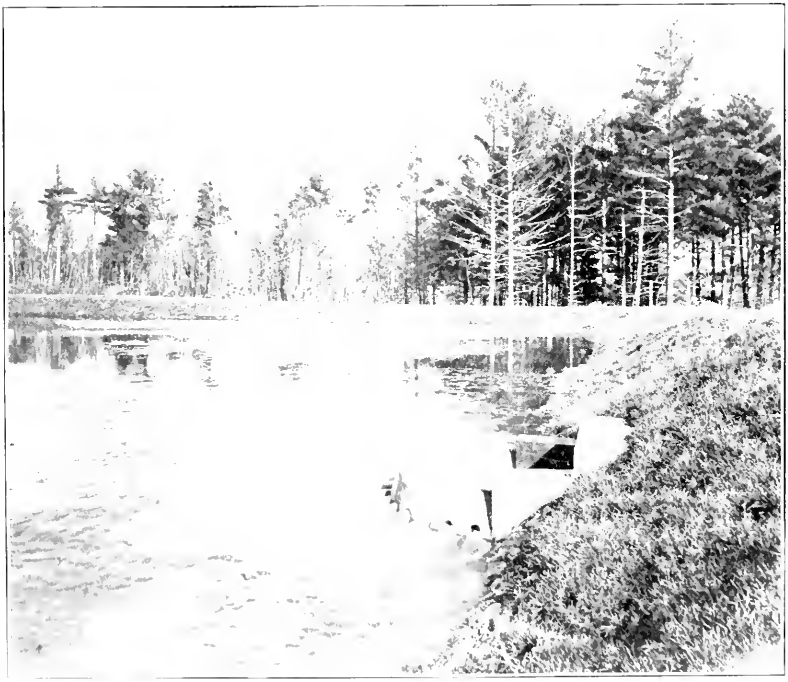


FIG. 8. CLINTON. VIEW SHOWING METHOD OF APPLYING SEWAGE TO FILTER BEDS.

year. The quantity amounts on an average to about 700,000 gallons per day. The sewage flows to a pumping station at the lower end of the city, where it is received in a reservoir intended to hold the night flow, from which it is pumped to the filtration area in the westerly part of the city, where 39 acres have been purchased, upon which 21.5 acres, divided into twenty-three beds, have been prepared for the purification of the sewage. The soil of the filtration area is very coarse and porous, and a sufficient amount of underdrainage has been provided for the removal of the effluent. A few of the beds are used as sludge beds to receive the heavy sewage which settles at the bottom of the tank, and which is drawn out therefrom at the last part of the day's pumping. Much solid matter collects on the sludge beds, which is removed and used as a fertilizer. The remaining beds require very little care.

ANDOVER.

Population in 1900 6,813

The sewers are constructed upon the separate plan, and have received thus far very little surface or ground water leakage, the average quantity of sewage amounting to about 125,000 gallons per day. The sewage from the greater portion of the town is conveyed to the filtration area by gravity, but the sewage from low areas in the valley of the Shawsheen River cannot be delivered upon the filter beds by gravity, and this sewage is pumped to the main sewer.

The town has purchased 30 acres of land for sewage purification purposes, upon which 4.2 acres of filters, divided into twenty beds, which are thoroughly underdrained, have been prepared for the purification of the sewage. The sewage is received into a settling tank, in which a portion of the heavier matters, or sludge, is allowed to settle, and is subsequently discharged upon sludge beds prepared for the purpose. The sludge, after drying, is removed from the beds and either deposited in low ground or used as a fertilizer.

SPENCER.

Population in 1900 7,627

The sewers of the town are constructed upon the separate plan, but many roofs have been connected, and the flow is increased considerably at times by storm water and by leakage. The average quantity of sewage amounts to about 375,000 gallons per day.

The sewage is conveyed by gravity to a filtration area, which comprises 22 acres, upon which 9.3 acres of filter beds have been prepared. The soil is very coarse and porous, and a very few

underdrains have been found sufficient for the removal of the effluent. All of the sewage is discharged directly upon the filter beds, which are raked from time to time when necessary, the small amount of solid matter being used as a fertilizer or deposited in the neighborhood.

SOUTHBRIDGE.

Population in 1900.................................10,025

The sewers are mainly constructed on the separate plan, but considerable storm and ground water find their way into them. The average quantity of sewage amounts to about 350,000 gallons per day. The sewage is conveyed by gravity to a filtration area, where 7.25 acres of filter beds have been prepared for the purification of the sewage, divided into seventeen beds, which are thoroughly underdrained. A settling tank has been provided for receiving the sewage, but has not, thus far, been used to any considerable extent. At times of wet weather much of the sewage is allowed to discharge unpurified into the Quinebaug River below the filter beds.

CONCORD.

Population in 1900.................................5,652

The sewage is collected into a separate system of sewers, the flow in which is greatly increased by leakage. The average flow at the present time is about 375,000 gallons per day. The sewage is collected into a reservoir near the Concord River, designed to hold the night flow, from which it is pumped to the filtration area, which comprises 14 acres of sandy land, upon which 3.3 acres of filter beds, divided into four beds, have been prepared for the purification of the sewage. The material is porous, and the level of the ground water a considerable distance below the surface of the beds, and no underdrainage has thus far been provided. All of the sewage is discharged upon the filter beds, and no attempt has been made to separate solid matters from the sewage.

WESTBOROUGH.

Population in 1900.................................5,400

The sewage is collected in a separate system of sewers, and flows by gravity to the filtration area, which comprises about 32 acres, upon which seven filter beds, well underdrained, aggregating four acres in area, have been prepared for the purification of the sewage. The average quantity of sewage amounts to about 200,000 gallons per day, but this flow is increased to about 600,000

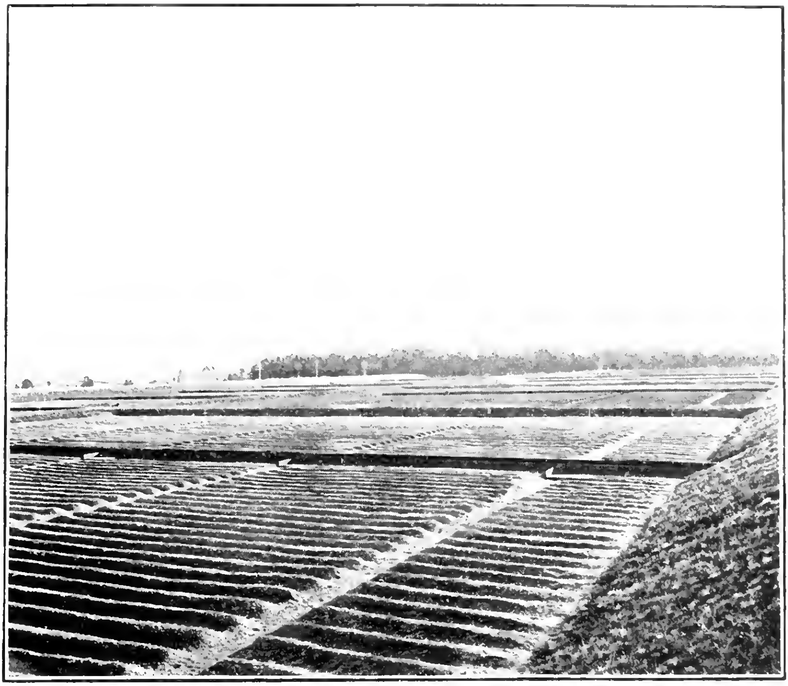


FIG. 9. BROCKTON. GENERAL VIEW OF FILTER BEDS.

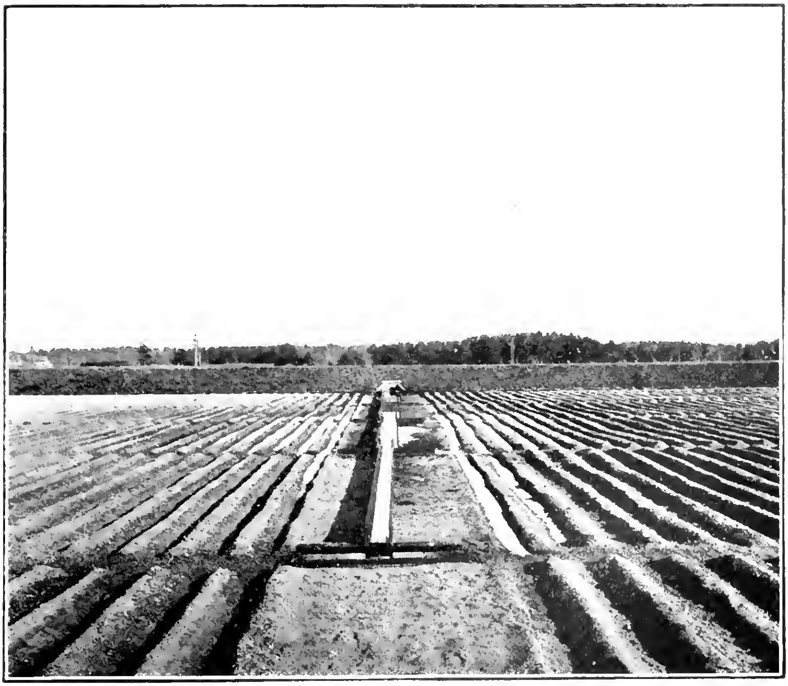


FIG. 10. BROCKTON. METHOD OF APPLYING SEWAGE TO FILTER BEDS.

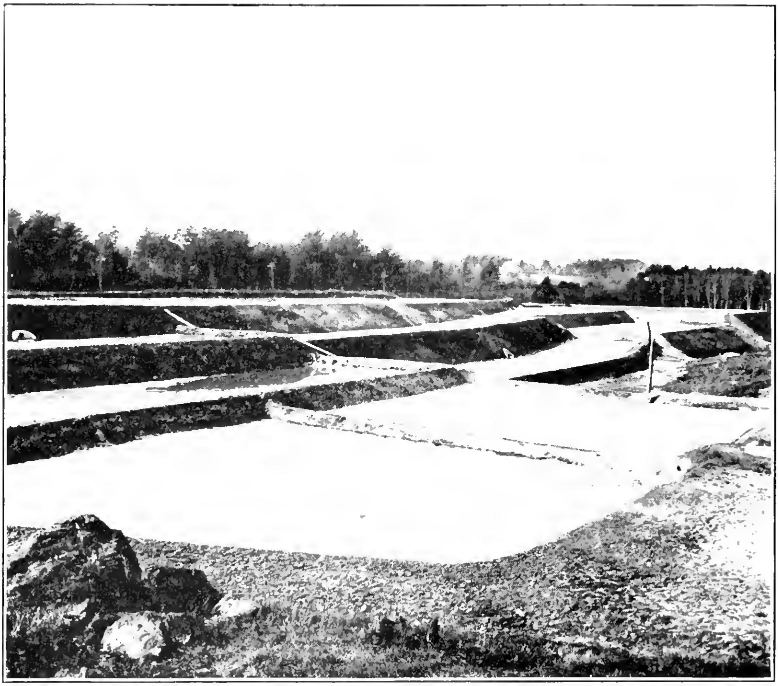


Fig. 11. Andover. General View of Filter Beds.

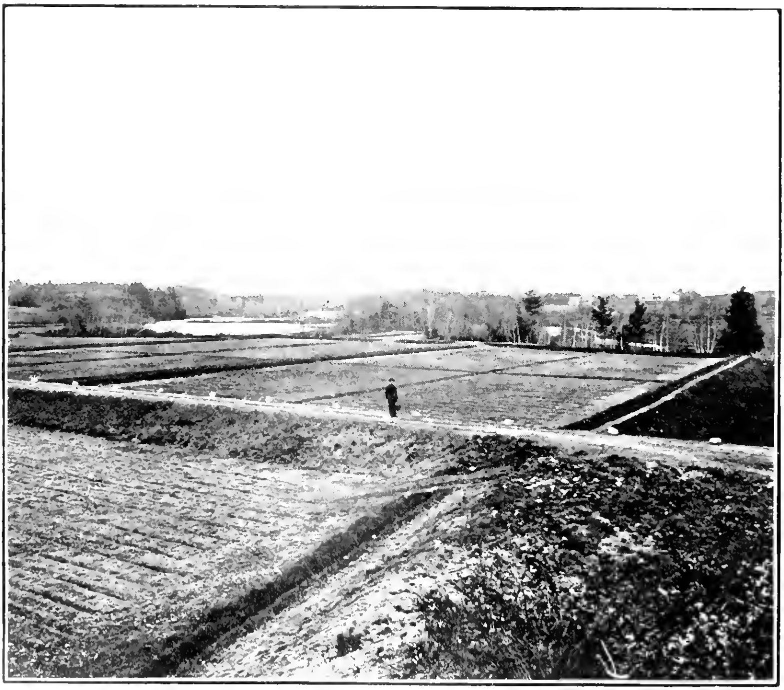


Fig. 12. Spencer. General View of Filter Beds.

gallons per day at times of wet weather, owing to leakage into the sewers.

At the filtration area the sewage passes through a small tank, in which a small quantity of solid matter is removed from the sewage before applying it to the filter beds.

NATICK.

Population in 1900 9,488

The sewers are constructed upon the separate plan, but a great quantity of ground water leaks into the sewers at certain seasons of the year. The average quantity of sewage amounts to about 600,000 gallons per day, and the maximum quantity to 2,200,000 gallons per day. The sewage is conveyed to a pumping station, near the southerly end of Lake Cochituate, whence it is pumped to a filtration area adjacent to that of the town of Framingham. About 97 acres of land were purchased by the town, upon which six filter beds, each 1 acre in area, have been prepared for the disposal of sewage. The beds are thoroughly underdrained, the underdrainage flowing into Bannister Brook, above the underdrains of the Framingham filtration area. All of the sewage is pumped to the filter beds, and no attempt is made to separate sludge from the sewage.

LEICESTER.

Population in 1900 3,416

The sewers are built only in the main village, and are constructed upon the separate plan, the average daily flow amounting to about 20,000 gallons. The sewage is delivered by gravity at a filtration area, comprising 9 acres, upon which seven filter beds, having a combined area of 0.35 of an acre, have been prepared, all of which are underdrained. At the filtration area the sewage is received in a large settling tank, the contents of which are occasionally discharged upon a special sludge bed, from which the sludge is removed after drying, and used as a fertilizer or deposited in the neighborhood. In addition to the filter beds there are two long trenches, into which sewage is occasionally discharged.

In addition to the filtration areas of cities and towns already described there are many such areas in use for the disposal of the sewage of public institutions which are of much interest. Among these are the sewage disposal areas at Danvers Lunatic Hospital, Foxborough Hospital for Dipsomaniacs and Inebriates, Westborough Insane Hospital, Rutland State Sanatorium and the State Hospital for Epileptics at Monson. There are also many areas in

use for private institutions, among which may be mentioned the filtration area used for the purification of the sewage of St. Mark's School in Southborough.

The Danvers Lunatic Hospital had a population in 1900 of about 1300. The total quantity of sewage amounts to about 150,000 gallons per day, which is delivered by gravity upon the filtration area, consisting of ten filter beds, aggregating 2.8 acres in area, all of which are underdrained.

The Foxborough Hospital for Dipsomaniacs and Inebriates contains about 200 people. The sewage is discharged by gravity upon four filter beds having an aggregate area of 1.12 acres. All of the sewage is discharged upon the filters, no attempt being made to separate sludge from the sewage.

At the Westborough Insane Hospital the sewage of 700 persons, amounting to about 80,000 gallons per day, is purified upon 3 acres of filter beds, which consist of very coarse soil. Underdrains were laid beneath these beds but no effluent has ever been collected in them.

At the Rutland State Sanatorium the sewage of a population of about 250 persons is discharged upon twelve small filter beds, aggregating 1 acre in area. This area receives little or no care, but all of the sewage is efficiently purified.

At the Monson Hospital for Epileptics most of the sewage is used for the irrigation of crops, but a small area of excellent filter beds has been prepared for use at times when the sewage cannot be disposed of by irrigation.

At St. Mark's School, Southborough, all of the sewage is disposed of on several small filter beds not far from the school.

FIG. 13. SOUTHBRIDGE. GENERAL VIEW OF FILTER BEDS.

FIG. 14. WESTBOROUGH. GENERAL VIEW OF FILTER BEDS.

Fig. 15. Leicester. General View of Filter Beds.

Fig. 16. Danvers. Danvers Lunatic Hospital. View of Filter Beds Prepared for Winter, Showing Method of Applying Sewage.

ADAPTABILITY OF THE MASSACHUSETTS METHOD OF INTERMITTENT SAND FILTRATION TO SEWAGE DISPOSAL PROBLEMS IN OTHER STATES.

By F. Herbert Snow, Member of the Boston Society of Civil Engineers.

[Read before the Society, November 19, 1902.*]

In discussing the subject which has been assigned to him, the writer proposes to allude to four typical problems outside of the State of Massachusetts, and, as introductory thereto, to touch upon the part which the Massachusetts State Board of Health has taken in developing and placing the art of sewage disposal upon a scientific basis.

EARLY HISTORY.

The outdoor closet or cesspool plan was the primitive system of household waste disposal. Next came the dry-pail method, involving the utilizing of the solids as a fertilizer. In fact, prior to the water-carriage system, which comprised the next step in the development of the art, soil was looked to as the only final means of disposal. But upon the general introduction of sewerage systems, the wastes of communities thus served were discharged into bodies of water which were supposed to be able to purify themselves, but which did so in part only. In consequence of this pollution, and to obviate it, the next step in the art was recourse to the purifying power of land, upon which, in many instances, sewage was required to be spread broadcast and utilized to fertilize crops. This method of disposal was called "irrigation." A later modification of it was called "intermittent filtration." Meantime, various methods of treating sewage had been invented, having for their prime object in every instance the removal of the solid matters from the main body of the liquid by such means as mechanical appliances or settling tanks, with or without the use of chemical precipitants, to facilitate the final purification of the sewage on land or to clarify and render it suitable to go into a body of water.

The exact process of purification taking place in the ground was not understood at this time. As far back as 1838, the germ theory of fermentation and decay had been advanced, and Pasteur, in 1860, had established it, but its significance in relation to practical sewage disposal matters was not grasped. But in 1870 it was demonstrated that there existed micro-organisms which were active

* Manuscript received March 21, 1904.—Secretary, Ass'n of Eng. Socs.

in a soil upon which sewage was turned, and in 1872 the scientific world accepted the fact that sewage matter was converted into nitrates by organisms present in normal sewage and soils.

By 1884 several scientists had demonstrated that oxidation of organic matters in sewage, when treated by irrigation or filtration methods, was caused by bacterial action, and not solely by chemical action, as previously supposed to have been the case.

This knowledge—that bacteria played an important part in assisting oxidation—was followed by efforts to facilitate conditions under which these activities occurred, and it was at this stage of the development of the art that the Massachusetts State Board of Health began its now world-renowned classical researches.

MASSACHUSETTS' CONTRIBUTION TO THE ART.

In reviewing the history of filtration in Massachusetts, we find, as early as the fourth annual report of the State Board of Health that the conditions of the Blackstone River, below Worcester, were therein noted and the possibility of disposing of the sewage of that city by intermittent filtration outlined.

Later, in the special report of 1876, it was pointed out that factory refuse and trade impurities were a great cause of pollution of streams, but that sweeping laws for the general and immediate purification of all these sewages were hardly justified in the then present state of knowledge of the subject. Nevertheless, the Board recommended that no city or town be allowed to discharge sewage into any water course or pond without first purifying it by irrigation.

The next year the Board recommended that no liquids of a deleterious character from new manufactories be discharged into a stream unless purified according to the best available means.

It is interesting to observe that there were then in use in England 59 sewage farms, 26 chemical precipitation works, 16 filtration fields, 10 plain subsident tanks and 3 intermittent filtration systems.

In 1882 the Board submitted a report to the Legislature on a definite plan of disposal of Worcester's sewage, recommending intermittent filtration. That city, however, successfully objected to being forced to embark on "a course of expensive experiments with little promise of success." Four years later an act was passed to establish a disposal system which, without limiting Worcester to any particular method, required the city within four years to purify the sewage so that it should not create a nuisance or endanger public health. This law materialized in the shape of a chemical precipitation plant, which was completed and put into operation in 1890;

three years later it was doubled in size, and in 1896 was reported by State officers as being inefficient to prevent the pollution of the Blackstone River. It was stated in the State Board of Health's report for that year that the pollution would increase until some more complete purification of the sewage was made; whereupon the town of Millbury brought suit to force Worcester to properly purify its sewage, and the court issued a favorable decree. Since which time the works have been enlarged and a few sand filters have been added.

In order to obviate local and selfish determination of sanitary questions, the Legislature of 1886 thought best to provide outside and dispassionate control of water supply and drainage problems, and the act of that year, entitled "An act to protect the purity of inland waters," marked the beginning of a new era in State sanitation. The law committed the general oversight and care of inland waters to the State Board of Health, and conferred power to employ experts and do various things, among which should be noted:

"1. The advising of cities and towns, corporations and individuals as to the most appropriate source of water supply and best method of insuring its purity and disposing of sewage.

"2. The chemical and other examination of water supplies and other inland waters.

"3. The collecting of information on purification of sewage on land and conducting experiments on such purification as are necessary to obtain knowledge for immediate use within the State."

The recommendation of the Massachusetts Drainage Commission that the Mystic Valley sewage be filtered on the Saugus marshes, and that in the upper Charles and Neponset and the Sudbury and Cochituate basins twelve independent intermittent filtration and irrigation systems be established, had much to do with the starting of the well-known important series of experiments at Lawrence. The report of the Board for 1888 states that on the basis of results of filtration experiments and practical experience in England and on the Continent, where various intermittent filters are reputed to be treating sewage at a rate of 36,000 to 90,000 gallons per acre daily, "We must enter upon experiments to determine the amount of sewage we can in this climate purify with such material as is deposited in our valleys. This knowledge can be obtained only by trial and careful observation, and to obtain reliable information and actual additions to the knowledge of the world upon this subject . . . . for an immediate and urgent use in this State . . . . the Board established the experiment station at Lawrence, and has begun the study of soils, sands and gravel to be found in the vicinity and after-

ward to be replenished by those which may be proposed for use in other localities."

The experience gained by these experiments on intermittent filtration of sewage through different soils early proved of efficient service in enabling the Board to decide many difficult problems presented for consideration by authorities of cities and towns, as fully appears in the annual reports, and as years went by, the act to protect the purity of inland waters proved to be one of the most useful laws in the history of State legislation. The work performed under its provisions by the State Board of Health has justly won a reputation among engineers, sanitarians and experts in this and foreign countries as standard work upon water supply and sewage disposal.

In 1889 the Board reported in regard to the disposal of sewage of the Mystic and Charles River Valleys, "upon additional information obtained by experiments and investigations of the past year, the Saugus marshes will not serve for a filtering area for the sewage of the Mystic Valley, and, as there is no other area available, its disposal by filtration must be abandoned."

The same year experiments on chemical precipitation were made, and in 1891 some work was done with manufacturing wastes. The next year investigation of purification of sewage containing dyestuffs as undertaken, and the report of the Board for that year contains descriptions of sewage fields built under its advice.

During 1893 experiments were begun upon rapid filtration of sewage from which sludge had been removed. Sludge removal by screening through gravel and coke, by sedimentation, chemical precipitation and mechanical devices were studied.

In 1895 the first experiments were conducted upon disposal of waste liquors from paper-making, wool scourings and tanneries. The next year fresh and stale sewage were specifically discussed and emphasized in the report, and two filters were put in to illustrate the difference in disposal.

In 1897 some studies of filtering manufacturing sewages were conducted away from the Lawrence Station, to find out if these sewages could be filtered and purified by the same processes successfully applied to ordinary sewage.

The report for 1898 goes on to say that the experiments on purification of sewage and various kinds of manufacturing wastes "has furnished new and useful information upon the practicability of purifying sewage at rapid rates and with various materials which are of value in many sewage disposal problems where land suitable for purification of sewage cannot be obtained."

Two septic tanks were started in operation at the Lawrence

Station that year. The term septic was attributed to the publication of certain English experiments. The report of the Board for the next year, during which year attention was paid to rapid methods —septic tanks and bacteria or contact beds—states that the "results of the septic tank process taken in connection with contact beds give promise of furnishing a means of purifying sewage in places where suitable land for the purpose is not available."

Thus reliable information upon the subject of the amount of sewage that can be purified in this climate with such materials as are deposited in the valleys was obtained and made public.

In England, where natural sandy deposits are not so available as here in Massachusetts, the septic tank system and contact filter systems have been perfected and used, and these methods have come to be considered and known as English methods, and intermittent filtration has come to be known and talked about as the American or Massachusetts method.

THE PROBLEM AT SARATOGA SPRINGS.

Coming to the adaptability of intermittent filtration to problems outside of Massachusetts, we will first consider Saratoga Springs, N. Y.

The normal population of this place is 12,000, and its summer population is at times over 40,000. In consequence of this fluctuation the seasonal changes in amount and quality of the sewage are unusual. The problem was still further complicated by a combined system of sewers and an abnormal water consumption.

An almost ideal territory for filtration was found, but to reach it required pumping.

Natural sand areas possible to reach by gravity were found to contain some clay intermixed with fine sand, which rendered their utility doubtful.

The estimated cost of a high-rate artificial plant on the most available gravity site proved to be in excess of the cost of the sand filter project finally adopted. By way of explaining this project, attention is called to the fact that there are certain features which demand special consideration in every problem.

One of these features relates to the handling of the solids. They may be removed from the bulk of the sewage by sedimentation, or by chemicals, or by liquefaction, or by mechanical devices. In each process the sludge is concentrated for further handling and disposal.

Liquefaction may be the cheapest method in some cases, because the solids in suspension are dissolved to a greater or less extent thereby, and to this extent effect economy in their subse-

quent treatment. These dissolving actions take place even in the sewers, but the bacteria which promote the process do not attain their greatest activities unless the sewage is brought to rest. The septic tank is a settling basin in which this period of rest is prolonged for this purpose and the solids are intentionally retained for an indefinite time.

At Lawrence the deposits in a tank after two years' operation were practically nothing, while the solids which entered the tank would without septic action have filled the tank five times.

When the sewage is suitable, this process of preliminary treatment of the solids and the liquid prior to the sewage going into a filter has much to commend it for consideration, and it was adopted in the Saratoga design.

Another feature demanding special consideration is the manner of effecting purification of the bulk of the sewage in the body of the filter.

If the dose of sewage is greater than the air capacity of the filter, which air capacity depends upon the size of the sand grain, there will be insufficient oxygen to promote the activities of the nitrifying bacteria, and consequently the filter will store up organic matter and in time become foul and useless.

Where there is an unlimited area of field or sandy plain, it matters not so much whether the engineer is ignorant or careless of the physical qualities of that particular soil and its maximum capacity to purify sewage; but where the filter has to be built of selected material brought from a distance, or in a locality on a side hill or uneven ground, where every cubic yard of material to be moved means considerable expense, the full capacity of the sand should be known and its maximum use planned for in the design.

It is along these lines that advancement in design is to be looked for.

The size of sand grain also has everything to do with the frictional resistance, which must be relied on to hold the sewage long enough to effect purification and yet not too long to hinder the maximum work of the filter.

It is therefore made plain that the dose of sewage should be proportioned to the sand capacity. This is a most important detail of design and also of operation.

Given in any particular case the size of the sand grains and a knowledge of the capacity of that class of sand, the arrangement for a corresponding dosing of the filter can best be secured by providing a chamber or chambers holding the requisite quantity of sewage and operated automatically.

Another feature for special consideration is the quality of the sewage. The amount of work to be performed in the filter is the total amount of organic nitrogen in the applied sewage to be transformed into nitrates. This varies greatly in different sewages. Its importance more particularly relates to the mode of preliminary treatment to be chosen.

Due consideration of these features resulted in the adoption of the Saratoga design, which comprises a station over a pump well at the end of the new outfall sewer, three centrifugal pumps operated by electricity, a receiving reservoir for prolonged sedimentation at the disposal fields, an aërating device for the effluent from the reservoir, an automatic dosing chamber, distributing channels for the sewage and 20 acres of sand filters.

THE PROBLEM AT LAKEWOOD, OHIO.

At Lakewood, Ohio, there were no natural sand deposits available. Sand might have been dredged from the lake, but the cost of doing this would have been excessive.

The choice of a system of disposal lay between a chemical treatment and a high-rate bacterial plant. The latter was selected on the score of adaptability and economy. It comprises a septic tank and cinder contact beds. To regulate the gravity flow to the tanks there are provided automatic orifices. Aëration of the septic effluent is effected in a chamber for that purpose, and a distribution of sewage at the beds and the collection of the effluent and its subsequent discharge into the river is done by means of gates automatically operated, so that no attendant is necessary.

The tanks hold 600,000 gallons. The beds cover $\frac{5}{8}$ of an acre, and are divided into five units.

Bacteria beds are structures in which, under conditions favorable to their existence, the organisms upon which the purification of sewage depends can grow and thrive.

These conditions imply the presence of dissolved oxygen in the sewage and the entrance of air through the entire depth of the bed between the doses of sewage. To make this possible the material must be coarse enough to reduce capillarity to a minimum and at the same time fine enough to intercept the comminuted particles of the organic matter.

The limit of size of bed material, as proved by experience, is from $\frac{1}{16}$ to $\frac{1}{2}$ inch, expressed in diameter of extreme particles. An extended and particular study of available material at Lakewood, supplemented by chemical and mechanical analyses, resulted in the selection of cinders from a large manufacturing plant and the re-

moval and rejection of the dust by a special screening device and the crushing and screening of the larger particles into proper sizes.

In operation four of the five beds are worked at one time, the fifth being thrown out of commission for periods of rest of a week or more. Of the four beds in use, one is filling, one is standing full, one is emptying and one is resting. The automatic mechanism not only effects this distribution at a great saving in cost of labor, but does it with a regularity impossible of attainment by manual manipulation.

THE PROBLEM AT MARION, IOWA.

This city built a system of sewers in 1893 with an outlet into Indian Creek. Suits for pollution of the stream were soon instituted and damages were awarded for depreciation of rental value of pasturage farms, the testimony going to show that cattle refused to drink the water and that other water had to be procured for the stock at great difficulty. In 1899 the writer went to Marion to see about plans for disposal works, and subsequently a high-rate straight-acting automatically operated intermittent coke cinder filter was designed (there being no sands available in this vicinity) embodying the preliminary treatment of the sewage by the septic process. The plans were duly adopted, and in 1900 the city proceeded to construct the septic tank.

The plant in its entirety was not designed to effect a high degree of purity. The stream at the point into which the effluent discharged had a watershed of about 75 square miles, and 3 miles below it entered the Cedar River, the intervening territory being sparsely settled and the creek water unused for domestic purposes.

Four nitrification beds, each $\frac{1}{10}$ acre in size, were proposed Suitable sands could not be obtained, so coke cinders were selected, effective size 1.62 mm., coefficient of uniformity 2.63, with a total air space equal to 40 per cent.

By an arrangement for the continuous discharge of the septic effluent into a dosing tank of 10,000 gallons' capacity, and the intermittent dosing of the four beds by an automatic siphon, and gates operating automatically, the sewage being delivered onto the surface of the beds by carriers, it was thought that an effluent would be obtained of sufficient purity to meet necessary local conditions. But for economic reasons the city constructed only the septic tank. It holds 150,000 gallons, and the flow from 2000 people connected with the sewers is approximately 200,000 gallons daily, so the time of passage of the sewage through the tank is about eighteen hours' duration.

The effluent is discharged into a stream whose minimum flow, 1.5 cubic feet per second, equals 0.75 cubic feet per second for 1000 people contributing sewage to the tank. The operation of this tank under these interesting conditions seems to be perfectly satisfactory to all concerned.

THE PROBLEM IN THE BRONX RIVER VALLEY, N. Y.

This beautiful valley, in close proximity to New York City, is destined to become populated with a prosperous class of people, and when that time shall have arrived undoubtedly a general sewerage system will have been adopted, comprising the conveying of all the sewage away from the valley and its disposal in connection with New York City sewage into tidal water. But at the present time the cost of such a general system is far beyond the financial resources of the valley, and therefore some other solution of the problem is demanded.

The city of Mount Vernon is in this valley. It has a population of about 25,000 people. Its sewage is discharged into the Hutchinson River, a tidal estuary of Long Island Sound.

The watershed of this river at the sewer outlet is only 7 square miles. About four-fifths of the population of this city use the sewers, so the pollution of the stream is very great.

A plan was projected to extend the outfall sewer to the Sound, and a route was chosen through Pelham Manor, New Rochelle and by Glen Island, so that these places could connect, but a bill authorizing the scheme failed of passage in the Legislature, because of the opposition of these places.

Along the shores of Long Island Sound, affording a possible site for tidewater disposal of Mount Vernon's sewage, there are communities, rapidly increasing in population, of a class which demands the maintenance of the highest sanitary standards, and it is reasonable therefore to conclude that the opposition to the discharge of crude sewage along their foreshores by a foreign municipality is of a permanent character.

Accepting this conclusion, the place to erect and operate clarifying works, if such a solution of the problem is to be sought, would naturally be the nearest available site to the present outlet into tidewater. Here the river joins the government canal, in which the tide rises and falls 7 feet, and its volume is sufficient to dilute a partially purified effluent, but not an effluent from which the suspended matters have been removed by a mere mechanical process.

Another plan which provided for the disposal of Mount Vernon's sewage and other places was projected. But it was abandoned,

owing to its excessive cost. It comprised the construction of an intercepting sewer in the valley of the Bronx, beginning at the village of White Plains and finally joining with the city of New York system.

In view of the probability of an ultimate general sewerage system for all the communities in the valley, any other plan should be considered as a temporary expedient and the ultimate abandonment of any structure erected thereunder should be contemplated.

At this juncture the question must arise as to the kind of a plant best adapted to these peculiar conditions. It is not the duty of State officials, having jurisdiction in questions of public health of this kind (which, because of their nature and extent, pass out from and beyond the control of local boards of health), to devise particular plans for any case, any more than it is the duty of local boards of health to devise a sewage disposal plan; the powers vested in the State department being largely of an advisory character.

The responsibility of the body or individual designing a plan is not lessened by the superior advisory or sanctioning power of the State, but it is just as great to thoroughly comprehend the problem and to devise or adopt the plans best calculated to accomplish the work. This fact is too often overlooked by City Councils. Plans have been adopted in places because they were approved by the State department, which department would undoubtedly have approved other plans better adapted by far to do the work had such plans been presented for consideration and approval.

In the case in question, the right solution of the problem calls for the exercise of the highest knowledge in the art of sewage disposal. A plant is called for whose time of usefulness is limited and whose ultimate abandonment is almost a certainty; during this period it must not create a nuisance; it need not completely purify the sewage; the degree of purity a plant may safely attain and not create a nuisance is involved in this question, and the permissible degree of pollution of the stream into which the effluent of this plant is to go is also involved.

Failure to properly comprehend these features and adequately provide for them in the design involves probable failure of the plant.

In spite of these facts the local government determined to advertise for propositions from owners of proprietary methods, the propositions to be received under general plans and specifications, to be prepared by the city's consulting experts.

The general plan provided for the purchase of 16 acres of land

at the existing sewer outlet. Subsequently $40,000 were paid for this tract. The sewage of the greater part of the city can be delivered to it by gravity flow, but certain areas are so situated that the sewage from them will require pumping. For this purpose the plan contemplated the installation of several small pumping plants at points most economical for the collection of the sewage from these areas and the raising of the sewage to the nearest point in the main conduit which serves the gravity district. The pumping units were planned to be operated by electric power derived from a power plant to be installed in the proposed power and crematory house at the disposal works. This part of the general plant was intended to be permanent in character, as were also the crematories provided for the disposal of city garbage and refuse and sewage screening and sludge.

The method of treatment of the sewage was, of course, left for bidders to propose, but the general specifications called for some kind of bacterial treatment, and the plant was required to have a daily capacity of 2,000,000 gallons of normal town sewage.

The village of White Plains, located in the same valley, has treated its sewage by chemical precipitation for a number of years.

The effluent of this plant has not been satisfactory. The decision of the court in respect to this matter was that the discharge from the works produced at times a foul and offensive odor and added to the discoloration and pollution of the Bronx River.

In view of the issues in the case—which case was most persistently fought through to the highest tribunal of the State—and the decision of the court, which was adverse to White Plains, it became necessary in planning new works to provide for obtaining a high degree of purity of effluent. But because this degree of effluent might never be actually required, since in this instance an effluent clear and odorless, though containing some of its original organic matter and bacteria, and though unsafe to drink, should answer all practical purposes, the plan proposed comprised two parts, one of which it was proposed should be built and operated to effect a substantial but not complete purification.

The question would then become one of fact whether such an effluent contributed in a material and practically measurable degree to the pollution of the river. If so, then the second part of the plant should be added.

This illustrates how the degree of purity a plant should attain may enter into a problem and affect the cost of the same. The first part was estimated to cost $70,000 and the second part $30,000 more.

The general scheme was similar to that proposed for Mount Vernon in respect to the ultimate abandonment of the works for treating the sewage; also, in so far as practicable, the money needful for immediate expenditure was to be put into permanent structures. For instance, the village needed a garbage disposal plant. Therefore, it was proposed to take advantage of the benefits resulting from the combination of sewage and garbage disposal to as great an extent as possible by locating the crematory at the present works, remodeling these works and thereby reduce by half the amount of labor otherwise necessary to operate independent garbage and sewage disposal plants.

This part of the project was intended to be permanent.

The plan, so far as it related to the disposal of sewage, involved the use of the present works as far as possible and the changing over from the mechanical process of chemical treatment to the natural process of bacterial treatment, on the score of saving in cost of operation and improvement in character of effluent.

To maintain the old works in operation during the five previous years about $10,000 were annually expended, and in spite of this outlay the plant proved unsatisfactory. It was estimated that the new works could be built and operated to give good results at a total annual cost for investment and operation of less than the total annual cost of enlarging and operating the old works.

SUMMARY.

The four types of problems cited in the foregoing discussion were, in their solution, closely related to the oxidizing principle of sewage purification, the authority for whose use in this country is found in the Massachusetts experiments.

Thus, in the Bronx River Valley case, while mere slow intermittent sand filtration was not feasible, owing to lack of available sand deposits and suitable territory, modifications of this oxidizing and bacterial process were found to be cheaper and better adapted to the requirements than any mere mechanical process. This was equally true with respect to Lakewood, Ohio, and Marion, Iowa.

The Saratoga problem is, of course, a straight out-and-out slow intermittent sand filter plant, with some novel features added to facilitate operation and insure success under the abnormal conditions obtaining especially with respect to the severity of the winter climate. This plant is thought, by the writer, to be a pattern of excellence in several particulars. Intermittent sand filtration is the only really reliable method of bacterial treatment of sewage to-day. Its limitations are known, and wherever feasible its adoption should

be advocated. But where the local conditions preclude its use, the engineer is forced to consider some one of the new and accelerated methods. Undoubtedly they can be made successful, but they are a more highly organized means of treating sewage than the ordinary sand filter, requiring more intelligent attention and being less capable of meeting fluctuations in quality and quantity of sewage, such as occur daily in many sewerage systems.

SEWAGE DISPOSAL SYSTEMS.

Discussion of papers of X. H. Goodnough and F. H. Snow, before the Boston Society of Civil Engineers, November 19, 1902.

Mr. Harrison P. Eddy.—I have been very much interested in the papers which have been read to-night, but I was not quite prepared for the obituary of the Worcester plant, and consequently failed to bring my apology for appearing here.

The estimated present population of Worcester is 127,500, based on the past growth for a period of fifty-five years. The amount of sewage treated daily during the fiscal year 1902 was 13,300,000 gallons, including storm water, limited in quantity only by the capacity of the outfall sewer. The dry-weather flow (June, July and August) averaged 11,260,000 gallons per day, amounting to 88.3 gallons per capita. The total cost of operating the plant, not including interest or sinking fund accounts, was $50,576.69; making the per capita cost 40 cents. The purification plant has cost approximately $500,000 to date, and about $1,000,000 have been expended in remodeling the sewerage system to facilitate the work of disposal.

Although Worcester is credited with being a very selfish city, it has probably spent more money in the attempt to abate the nuisance in the Blackstone River than has been spent in sewage disposal by any city in the country, except possibly very large cities which dispose of sewage into tidewater. Worcester was unfortunately situated, at the time the sewage disposal problem came up for final action, in that it had a combined system of sewers; not only that, but its sewers had been discharging throughout the city into a trunk sewer, which was originally a brook or river, flowing, in dry weather, about 5,000,000 gallons in twenty-four hours; in freshet, 200,000,000 or 300,000,000 gallons. These features have constituted real difficulties; financial as well as engineering difficulties.

In 1890 the city of Worcester began to operate a chemical precipitation plant. It did not take care of the entire flow of sewage. It was deemed wise to begin with the treatment of the sewage rather

than the reconstruction of the system, for various reasons. In 1893 the plant was increased, and has been increased from time to time ever since. First, minor additions, then more basins for precipitating the sewage; then a plant for taking care of the resulting sludge, and eventually the introduction of filter beds, some of which are now being built. It was impossible to treat the whole of the sewage so long as it mingled with this river, and consequently the city has just completed the building of two intercepting sewers, at a cost of about $1,000,000. In addition to this it will be necessary, before the entire flow of sewage can be treated in time of storm, to have a complete separate system of sewers, so as to take the sewage without installments of storm water, or to greatly increase the size of the purification plant. One or the other must be done if all the sewage must be treated at such times. You can readily see that with 150 miles of sewers this is somewhat of a problem, a financial problem at least. Other difficulties have been encountered there. Worcester is a manufacturing city; there are tanneries, and their sewage has its effect more particularly upon the chemical treatment than the filtration. There is, however, one quality of the Worcester sewage which makes it different from that of most cities in this country, and that is its acid nature. Worcester's largest industry is a branch of the American Steel and Wire Company; large quantities of wire are dipped in vitriol, and the resulting sulphate of iron is turned into the sewer to a large extent, although some of it is recovered and utilized. As much as 100 tons of copperas could be made from the liquors that are found in the sewage waste in a single day; that, however, is exceptional, the average being considerably below that. I mention this merely to show that there is some difficulty in the way of handling successfully the problem at Worcester. Not only is the copperas serious as to chemical treatment—although it is of some benefit—but it is a handicap in that much sludge is produced, and it is a very serious element in the filtration of sewage. When this copperas or sulphate of iron comes through the series of settling basins, not having been treated with chemicals, very little of it is removed from the sewage. It is then turned onto the filters and they succeed in removing quite a portion of the iron. As high, during certain periods, as 50 per cent. or more of this iron is precipitated in the filter largely in the upper portion, in the form of sulphide of iron, sometimes in other forms, oxide of iron, etc., and it seems to be quite a factor in the clogging of the upper layers of the filter.

There are some interesting things in connection with this precipitation or clogging of the iron in the filter, I think, as at certain

times and in certain conditions of the filter the iron is washed out to a limited extent, and it leaves a large amount of suspended oxide of iron in the water, which, of course, makes it rather unsightly. The amount of oxide of iron contained in the sand, after being used for some time, will run as high as 4 or 5 per cent. by weight, and this reduces in the first 6 inches or 1 foot down to less than 1 per cent., and the lower portion contains comparatively little iron. So much for what constitutes the problem at Worcester.

The chemical precipitation plant has been in operation—as I have stated—since 1890; it has cost a great deal of money, as has been mentioned, but under the circumstances it could not readily be abandoned. I think those who best appreciate the problems there to-day feel that there is grave doubt if it can be abandoned in the future for methods which we now know of. Numerous experiments have been made there from time to time, and among others is one of some interest to us, that of the septic tank. It has been found that the action of bacteria directly or indirectly—probably indirectly—causes precipitation of the iron from the soluble form to the suspended, in the form of sulphide of iron, and it is not, perhaps, too much to hope that a tank might be so constructed that this iron would be to a large extent removed from the sewage by the septic process; on the other hand, precipitated in that finely divided form, it is very easily oxidized back to the sulphate, in which state it is readily dissolved by the water and carried out of the septic tank and onto the filters. A large tank, holding about 350,000 gallons, has been used as a septic tank for a time. The results obtained with this acid sewage do not vary greatly from those of domestic sewage; there are some minor details of variation. The effluent from the septic tank running under the conditions which have been tried is exceedingly offensive.

The population in the vicinity of the tank is growing; new houses are being built from time to time in the immediate vicinity, so that the problem of odors is one to be seriously considered. The problem of odors from the septic tank—as considered there—is not so serious as the problem arising from the odor given off by the water as it is spread upon the filters. The area of the septic tank—even though it is not covered with scum—is comparatively small, but when this amount of water is turned out onto the filters it is exposed to the air, and there is a very large surface of water from which the offensive odors can arise.

I don't know that I can add anything more that will be interesting. I shall be very much pleased to see this Society in Worcester at some time to visit our works. They are still in operation!

CHEMICAL EXAMINATION OF SEWAGE AND EFFLUENTS.

			Sewage.	Chemical Effluent.	Filtrate
Ammonia	Free		2.254	2.320	1.082
	Albuminoid	Total	1.121	.524	.083
		dissolved	.375	.394	.083
		Suspended	.746	.130	.000
Nitrogen as	Nitrates		—	.157	.454
	Nitrites		—	.0349	.0189
Oxygen consumed	Unfiltered		15.25	6.90	0.76
	Filtered		8.80	5.62	0.76
Chlorine			12.48	11.31	10.55

NOTE.—An average of 150,000 gallons of chemical effluent have been filtered per acre per day.

The above are the average analyses of sewage, chemical effluent and filtrate from the filter beds for the last fiscal year.

PROF. L. P. KINNICUTT.—I am sure that we all feel greatly indebted to Mr. Goodnough and Mr. Snow for the two interesting papers that we have heard to-night, and we all feel proud of what Massachusetts has done and is doing toward solving the various problems of sanitary science.

There is no question that the world owes to Massachusetts the process of intermittent filtration for the purification of sewage; for, though it was known as early as 1865 that the putrefying substances in sewage could be removed by filtration through sand, it was the work of the Massachusetts State Board of Health that proved that this method of treating sewage was practicable on a large scale. Mr. Goodnough has shown us this evening how widely this method is now used in Massachusetts, and with what excellent results. Still, as Mr. Snow has said, this process is unfortunately not by any means always possible; it requires not only a comparatively large area of land, but also land of the right character—*i. e.*, sand of a certain size and uniformity—and when this does not occur in the near neighborhood of a town or city, that town or city must use other methods of sewage treatment.

As to the process of intermittent filtration, if the plant is well designed and carefully operated, it is sure to give good results; but no greater mistake can be made than to leave a well-constructed plant to the care of an untrained man, and, in my opinion, no better use could be made of a part of the money received by the Board of Health from the State than to employ a thoroughly trained man, whose whole time should be given up to visiting the various intermittent filtration plants in Massachusetts, watching the working of these plants and showing how they should be operated.

The newer methods of treatment, methods for towns or cities where intermittent filtration is not possible, are the result of investigations made in England, and experimental work in England is done on a much larger and more practical scale than in this country. The experimental septic tanks at Manchester and Leeds have a capacity of over 20,000 gallons; the experimental contact beds that I have seen in England were never smaller than one-seventieth of an acre, and ran from that size up to one-half an acre (the size of those at Birmingham), and the experimental percolating filters are also built on the same large scale. Is there not in this a lesson for us?

Contact beds when well designed and carefully operated are successful. The only question is the cost of maintenance, and this depends upon how long a contact bed will continue to work before the filling material will have to be removed and washed. Personally I think the danger of permanent loss of capacity has been exaggerated.

The continuous intermittent or the percolating filter is the newest method for treating sewage. These filters certainly treat a very much larger amount of sewage per given area per day than any other sewage purification process. The effluent though containing suspended matter (which, however, is only slightly putrescible) contains a very large amount of nitrogen in the form of nitrates. Under certain conditions I am persuaded that percolating filters offer the best and cheapest method of removing the putrescible substances from sewage, and I am not sure but that in certain places in southern New England they could be used to advantage, though I doubt if in northern New England the results would be satisfactory during the winter months.

I have already taken too much of your time, especially at this late hour of the evening, and I will only say one word more, and that is, that though we are well on the way toward satisfactorily solving the problem of the treatment of domestic sewage, yet there is still room for investigation and study, especially as regards sewage containing large amounts of manufacturing waste.

Mr. Freeman C. Coffin.—The pictures on the slide recall some of the first work that I did in connection with sewage disposal. The engineer in charge of the designing and construction of a sewerage system at Marlborough had very little precedent to follow in designing the filter beds, and it was a good deal like working in the dark. The system was designed in 1890 and built in 1891. The tank which received the sewage—curiously enough—was in some respects quite similar to the present septic tank. The sewage came in about at the flow line, and was held by a partition in the tank,

over which it flowed in a thin stream. After that it flowed through a screen and passed out into the outlet sewer. The sludge was deposited in this tank above the partition, and the conditions there were such that it could be drawn off from the bottom of the tank by gravity onto the sludge beds. I have not known much about the operation of these beds. I believe that they have been entirely successful, and the area, according to the figures given, has not been increased since the original installation. I was somewhat surprised at this, as I thought it had been increased.

In following the discussion to-night it has occurred to me that sometimes difficult problems of sewage disposal are connected with very small plants. Last year I was asked to design a system for disposing of a small amount of sewage, about 7000 or 8000 gallons a day. The conditions were these: The sewage must be disposed of on the premises. (It was for a school in Wellesley, in a thickly settled part of the town, with something like 100 to 150 inmates.) The sewage was originally disposed of, or supposed to be disposed of, by a subsoil system, which was totally ineffective; the crude sewage was flowing into a stream. The Park Commissioners notified the authorities of the school that this must not continue. It was expected that the town of Wellesley would have a public sewerage system within a short time, and it was desired to avoid expense as much as possible. The conditions for disposal of this sewage without committing a nuisance and without polluting the stream were very difficult. The grounds were limited, something like two acres, which included the buildings and all the grounds they had. There was in my opinion no possibility of disposing of the sewage effectually by any subsoil system. It was rather difficult to determine what to do, but eventually the following plant was designed and constructed: a regular sand filter, entirely artificial, and in connection with it, for preliminary treatment, a coke strainer following out the suggestions of the experiments of the State Board of Health. It was designed on as economical lines as practicable, knowing that it was possible that the capacity of the plant would have to be increased. The sewage is taken into a small pump well and pumped by a gasoline engine, direct connected to a centrifugal pump. A septic tank was considered, but on account of the danger of odors it was not adopted. The plant was covered with a roof above the ground. One of the disadvantages I have found with a filter bed under a roof compared with outdoor beds is that there is no drying off of the sludge under a roof, which makes the sludge problem more difficult. I was somewhat disappointed in the action of the coke filter that it did not remove any more of the sludge. The coke filter was designed for a

rate of about 1,000,000 gallons and the sand filter for about 300,000 gallons per acre per day. This plant went along all right until last spring, when I was notified that it would not work, that the under-drains were all clogged up and no sewage could get through. An examination was made, and it was found that there had been no removal of the sludge from the surface of the beds and the filter was completely choked up. After investigating the matter and asking many questions we were informed by the man who had it in charge that their method was not to remove the sludge as directed, but to dig it over and let the sewage through; when this failed they got a negro to come there and run a bar down in different places until the sewage disappeared. They kept it going until about the first of May in that way, when they could not make it go any longer and the sewage began to run out over the sides of the bed, and they sent for me. About a food of sand and sludge was removed and the filter put in good order again. We left written directions as to how the plant should be operated, and it went along all right until this fall, when we were notified again that it would not work; that they had carried out the instructions carefully, but it would not go. We examined it again and the same conditions were found to exist, although not quite so bad. There were about 3 inches of sludge to be raked off. I don't know what the results now are, but aside from these times it has taken care of the sewage very satisfactorily, and there was no odor, except possibly a little inside of the roof from the pump well. I hope that if it is handled properly it will keep going until the town provides a public system.

MR. F. P. STEARNS.—I have not studied at all carefully the methods of sewage disposal which have been advanced in recent years; but, from what I have read and heard regarding them, and particularly from the statements which have been made to-night by Mr. Goodnough, I feel that it will not be necessary for the present, under the conditions which generally obtain in Massachusetts, to consider at all fully anything but intermittent filtration. In nearly all parts of Massachusetts there are suitable conditions for this method of disposal.

As I cannot add anything of value to the discussion of methods, I will present a summary of the results obtained with the works for the disposal of sewage by intermittent filtration built by the Metropolitan Water Board at Clinton. These works include intercepting sewers, a receiving reservoir and pumping station and $23\frac{1}{2}$ acres of filter beds in a territory of upwards of 100 acres. The cost of these works, exclusive of land damages, was $104,000, and including land damages, which, owing to the circumstances, were excessive in com-

parison with the actual value of the land, about $142,000. The cost of pumping the sewage for the last three years has averaged $2300 per year, and of maintaining the filter beds, screeens and sewers $2400 per year. Several buildings were included with the land taken, and the revenue for rent received from these buildings and from other sources amounts to $400 per year, so that the net annual expense, exclusive of fixed charges, is $4300. The fixed charges may be reckoned at 5 per cent. on the cost of the works, equal to $7100 per year, making the total annual cost, including fixed charges, $11,400. As the town of Clinton has a population of about 14,000, the cost of disposing of the sewage by this system, which provides a thorough purification of the sewage, is about $0.81 per inhabitant, which does not seem to be an unreasonable price for disposing of the sewage of an inland town.

Mr. Geo. A. Carpenter.—I have been pleased with the papers read to-night and with the slides shown upon the screen. I have been impressed in particular with the large areas used by, or at the disposal of, the various cities and towns of Massachusetts in which sewage disposal systems have been constructed, as compared with the area in use in my own city, Pawtucket, R. I.

In Pawtucket we have been studying the problem of sewage disposal by intermittent sand filtration since 1894, and have also conducted some experiments with the septic tank.

Only a portion of our sewers, 13.22 miles, are in the section connected with the filter fields. The population within the territory sewered is about 7300, but the population actually connected is only about 5100. Last year an average of 133,000 gallons of sewage per day were treated, the maximum for a month being 171,000 gallons per day.

The sewage is very strong, averaging 1.41 parts of albuminoid ammonia per 100,000, and comes to the plant fresh from the connections, with very little time for any breaking up of the organic matter or for any septic action before reaching the collecting tanks. It is domestic sewage almost wholly, there being no large amount of manufacturing wastes present.

We have had in actual service 2.35 acres of sand beds and are now constructing 1 acre more. The original area is divided into 13 beds of varying size. Four of these beds are known as sludge beds, and receive the settled sewage from the lower 6 inches of the tanks at a rate of 80,000 gallons per acre. They are dosed in rotation and sewage is applied to each of these sludge beds every fourth day.

The remaining beds are also dosed in rotation, but at a rate of

100,000 gallons per acre. Figured on the basis of 365 days in the year, these beds have received the equivalent of about 64,000 gallons per acre per day for each day in the year.

The effluent from the sand beds shows a removal of 92 per cent. of the organic matter in the original sewage, as represented by the albuminoid ammonia, and shows the presence of 2.71 parts of nitrates per 100,000.

No matter what the method of treatment may be, except direct disposal into tidewater, there will always be a certain amount of sludge, varying with the strength of the sewage, which must be handled in some form. My experience would indicate that the sludge obtained by sedimentation and drawn off each day upon sand beds is more easily handled than in any other form.

In ordinary weather, from the last of April to the middle of November, sludge collected and treated in this way will quickly dry out, losing a large percentage of its moisture. After that it can be raked from the surface of the sand and composted, buried, or burned, if proper facilities are provided. During the winter season the sludge cannot be as conveniently handled in this way. If turned on sand beds it does not readily dry out, but accumulates in large quantities on the surface, and after repeated dosing is apt to throw the bed out of service altogether.

Right here, it seems to me, the septic tank may perhaps be introduced with profit. The septic effluent, freed from a large part of the matter in suspension, can be readily disposed of on the sand beds, and the accumulating sludge—and I believe it will be found that sludge *will accumulate* in all cases with a domestic sewage of any considerable strength—can be taken from the tank in the spring and then disposed of.

Sludge from the septic tank is much more offensive and more difficult to handle than sludge obtained by sedimentation which is raked each day from the surface of the sand. But the septic tank will relieve the sludge beds in winter weather, the most trying season, and in this way may be made a valuable addition to a plant for the disposal of sewage by intermittent filtration.

An interesting peculiarity noticed in the action of the septic tank was the steady accumulation of sludge in the bottom of the tank for the first four months, until about 30 per cent. of the capacity was thus occupied. Upon measuring the sludge the next month it was found that it had risen from the bottom and now floated at the surface, and that the amount had been reduced, in one instance, about 40 per cent. and in another about 28 per cent. The first time this reduction was noticed it was presumed some mistake had been

made, but a repetition of the measurements proved that they were correct.

It would seem that in the operation of the tank the sludge gradually settles to the bottom, where it is acted upon by the bacteria, is gradually lightened and finally rises to the surface. It seems probable that at such times a considerable amount of the matter in suspension may pass off in the effluent, which would account for the reduction in the quantity of the sludge which was observed.

It should be stated in this connection that the septic experiments were made in one of our settling tanks, having an area of 3000 square feet, but the depth at which the sewage could be held was only 3 feet.

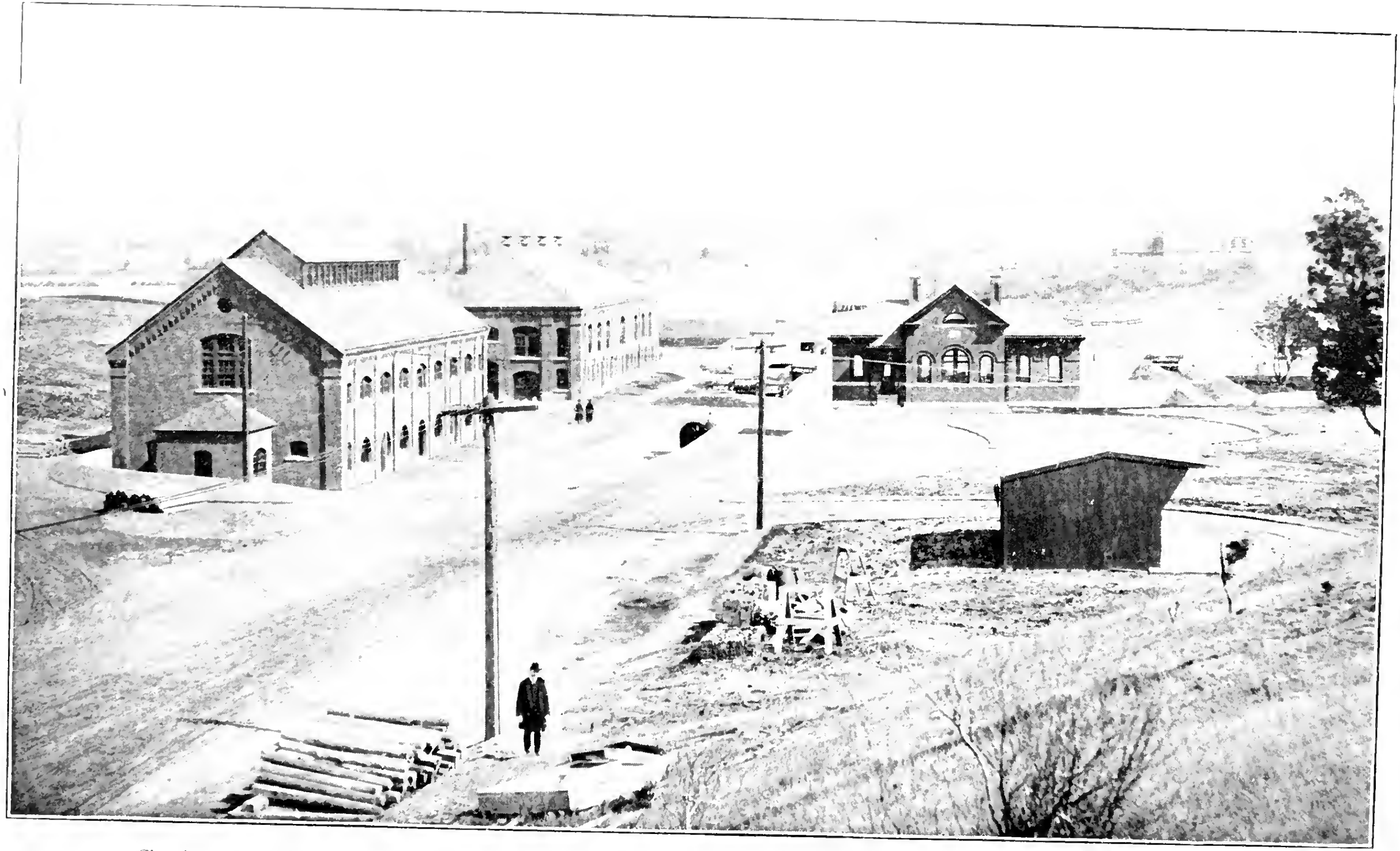
The first accounts of the working of the septic tank which came to this country from England led engineers to believe that its installation meant the end of the sludge problem; that it would maintain itself without any accumulation of sludge. I do not believe that can be shown to be true in any case where a strong domestic sewage is treated.

One difficulty which I have encountered in my efforts to collect information regarding the operation of various plants throughout the country—outside the State of Massachusetts—is the fact that very little detailed information regarding the strength of the sewage, the purification effected by the process, or the amount of sludge accumulated in the septic tank accompanies the reports or statements made respecting the workings of such plants. Statements are much too general, and some uniform system of recording data should be adopted, so that comparisons might be made.

I know that, to a large extent, engineers themselves are not responsible for this lack of detailed information, for municipalities are generally unwilling to grant permission to incur the expenses contingent upon such work. Generally, however, it is money well invested, for one city profits by the experiences of another, and each should do its part in promoting any work relating to the protection of the public health and the improvement of municipal conditions.

Mr. T. Howard Barnes.—I would cite an instance where the experiments made by the Massachusetts State Board of Health have pointed out the possibilities and limitations in the disposal of sewage with sufficient clearness to enable me to plan safely, under conditions differing from those at the place of experimentation.

I would say, in passing, that the boldness required in the case of Gardner or of Brockton, in the early days of Massachusetts filtra-



Chemical House. Press House. Laboratory.

PROVIDENCE PRECIPITATION PLANT

Providence Precipitation Plant, from the Southeast

tion systems of sewage disposal, is not now demanded in applying these experimental data to actual works. The splendid demonstrations of the reliability of these data give the force of actual assurance in applying these results to practical ends.

The instance referred to is that of a Southern city, where frost is not troublesome. The sewage would so rapidly reach the outlet as to be perhaps not even stale. The value of the sewage for irrigating purposes was also a factor, especially as it was possible to distribute it by gravity. There existed abundant areas of sand analyzing 155/1000 mm. effective size, and with a uniformity coefficient of 2.15. Having this fineness, the importance of avoiding surface clogging is apparent.

The conditions, briefly stated, then were: (1) A fresh sewage; (2) a filtration area of fine sand; (3) a high average temperature, without freeezing conditions; (4) an easily developed irrigation adjunct.

The value of simple subsidence, as demonstrated in the Lawrence experiments, was the *first* suggestion of particular import. As there demonstrated experimentally, a period of four hours permits rates of filtration of the liquid sewage about double that of sewage simply staled and unscreened. This process had further value in this instance in (1) carrying the sewage to the point of staling or further, and (2) its adaptability to another requirement incidental to all small plants, namely, that the care thereof should be as far as possible automatic. The process of subsidence, therefore, might be accomplished, to a large extent, in the reservoirs needed to detain a quantity of sewage for automatically periodical discharge.

The *second* suggestion deduced from the Massachusetts experiments was the danger of protracting the subsidence and consequent septic action. The experiments made upon Andover sewage showed that a point in septicizing sewage might be reached when toxic elements would be evolved. With a prospective value of the sewage for irrigation, such a consequence would be fatal to the usefulness of it for this purpose, to say nothing of the effect upon the degree of purification obtainable upon the filtration areas.

To meet this point of objection, and to permit a study of the "individuality" of the sewage in its particular surroundings, the receiving reservoirs were designed with compartments capable of being used singly or together. This affords a variable period of detention, also an opportunity to throw one of the subsidence compartments out of commission, while another is being used. A

sludge bed was designed, so situated and connected, that the sludge might be removed to it by gravity. Then, too, an opportunity was afforded for the sludge to undergo septic action, if found desirable, in order to liquefy some portion of the mass.

The works are not yet built, but are cited as an instance, as at first stated, of the great value which the Massachusetts experiments have been in meeting conditions not found in this State.

MR. OTIS F. CLAPP.—The city of Providence has adopted the "chemical precipitation method of sewage disposal," the conditions being such that other methods could not be used on account of a want of room within the city limits, and the great expense which would be involved in carrying the sewage to distant points. The subject was thoroughly investigated, and Mr. S. M. Gray, then City Engineer, was sent to Europe to examine the existing systems in use there, his recommendation being for chemical precipitation.

Providence has a population of 181,000, and is situated at the head of Narragansett Bay, 30 miles from the ocean. The shores of this bay are dotted with summer cottages and pleasure resorts, and its waters are used for fishing and the cultivation of oysters and clams. The necessity for removing, so far as possible, any pollution from these waters can be readily seen.

The sewerage system comprises about 190 miles of sewers, about 164 miles being in the regular system and the balance is what is termed the improved or intercepting system; also a sewage pumping station and a precipitation plant. The latter system of sewers, begun in 1890, was so far completed by the spring of 1897 that the pumps were started and the crude sewage emptied at Field's Point.

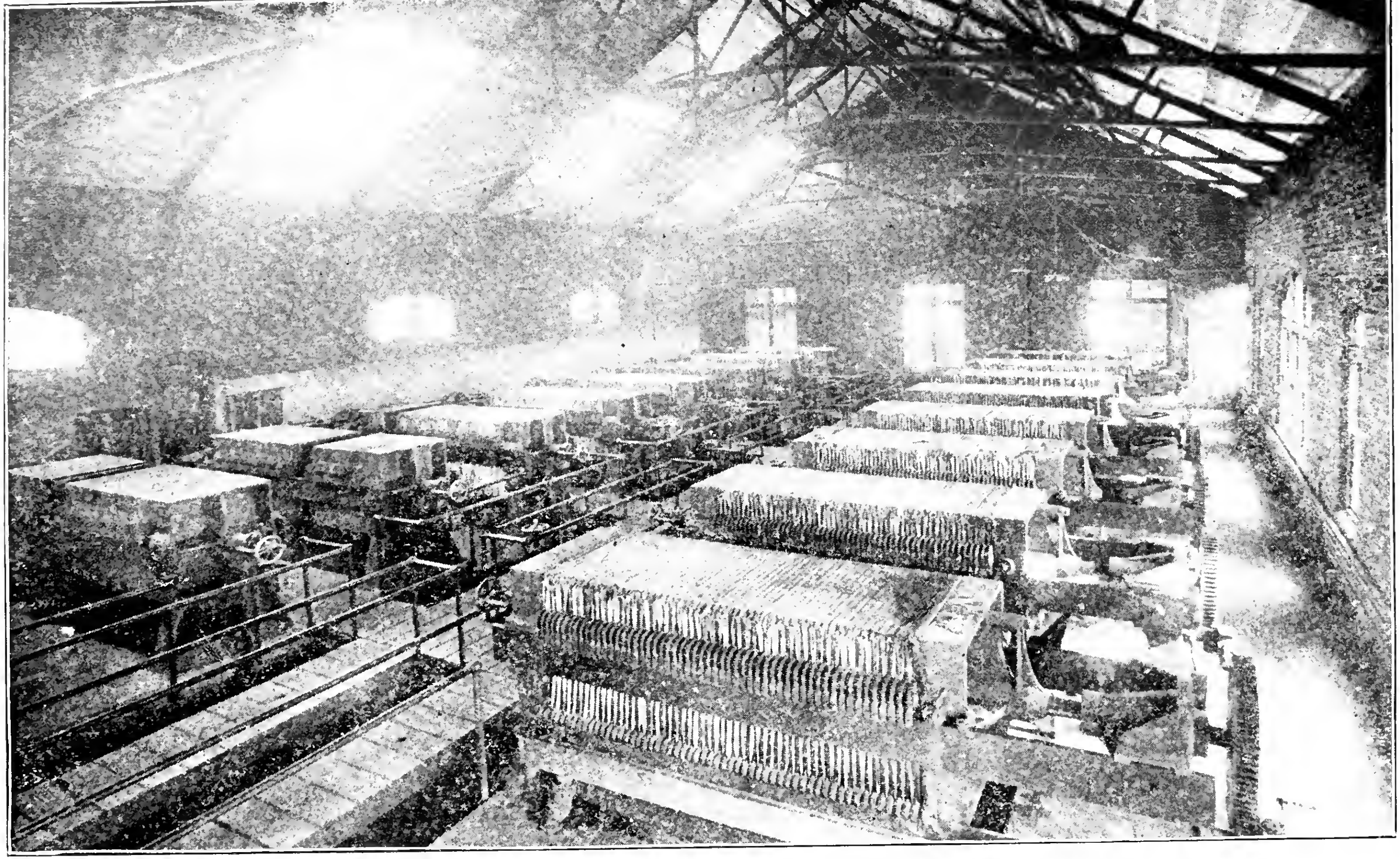
In 1898 the construction of the precipitation plant was begun, and by September, 1901, continuous treatment of sewage was started, and since January 1, 1902, the full plant has been in operation.

The daily average flow for dry weather is not far from 16,500,000 gallons. This sewage is very strong in the daytime, containing not less, probably, than 6,000,000 to 7,000,000 gallons of wastes from woolen mills, dye works, print works, bleacheries, soap works, jewelry manufactories, etc., which together produce a very dark mass, changeable in color and strongly alkaline.

The chemicals used are lime and sulphate of iron.

The pressed sludge is now being used for filling, although the works are so constructed that the wet sludge can be discharged from the sludge reservoirs into vessels and taken out to sea.

The precipitation plant consists of 20 concrete tanks, 4 large or



Press Room.

PROVIDENCE PRECIPITATION PLANT

roughing tanks, about 100 feet square, and 16 smaller ones, called finishing tanks, 60 by 115 feet, with 5 sludge reservoirs, a press house, a chemical building and a laboratory and office building.

Eighteen of the tanks are contained in a rectangular area, 270 by 670 feet, with 2 roughing tanks extending to one side, the whole covering an area of 5.03 acres and having a cubic capacity of 11,-133,000 gallons.

The sewage, after passing through a mixing channel, enters the roughing tanks; surface channels are arranged so that the effluent from any roughing tank can be conveyed to any finishing tank through a central channel running lengthwise of the group of tanks; the inlet into the finishing tank is regulated by a gate and a weir across the end of the tank, the outfall being over a weir, which is also the whole width of tank, thus securing an even and steady flow through the tank. When a tank is to be cleaned the clear effluent is drawn off through a floating weir into channels constructed in the masonry walls, and the sludge is discharged through open channels in the corridors, arranged so that the whole length can be inspected and cleaned. The sludge is brought to a sludge well situated close to the press house, from which it flows into the Shone ejectors, situated in a well inside of the house. The ejectors (two 500 gallon) raise the sludge about 50 feet into reservoirs back of the building, thence it flows to the forcing receivers, steel tanks 12 feet long by 8 feet in diameter, to which compressed air of from 60 to 80 pounds pressure is applied and the sludge forced into the presses; the effluent is sent back through the tanks again and the sludge is carried away in steel cars drawn by a small steam locomotive to the dump.

The pumping and pressing is done by compressed air, for which purpose two Rand air compressors are used. These compressors are driven by electric motors, one of 50 and the other of 150 nominal horse power. Electricity for power and lighting the works is furnished by the local electric light plant, and is of the 3-phase type.

The presses were made by John Johnson & Co., of New York; they are the regular English type, with 3-foot square plates, and make $\frac{3}{4}$-inch cakes.

The character of the sewage, and therefore of the sludge, varies with almost every place, depending mainly upon the number and character of the manufacturing industries existing there.

While it is early yet to give results, not having finished a year of work with the full plant, the appearances look favorable, and give us good reason to believe that we shall not be behind older plants of the same character. Our manager and chief chemist, Mr.

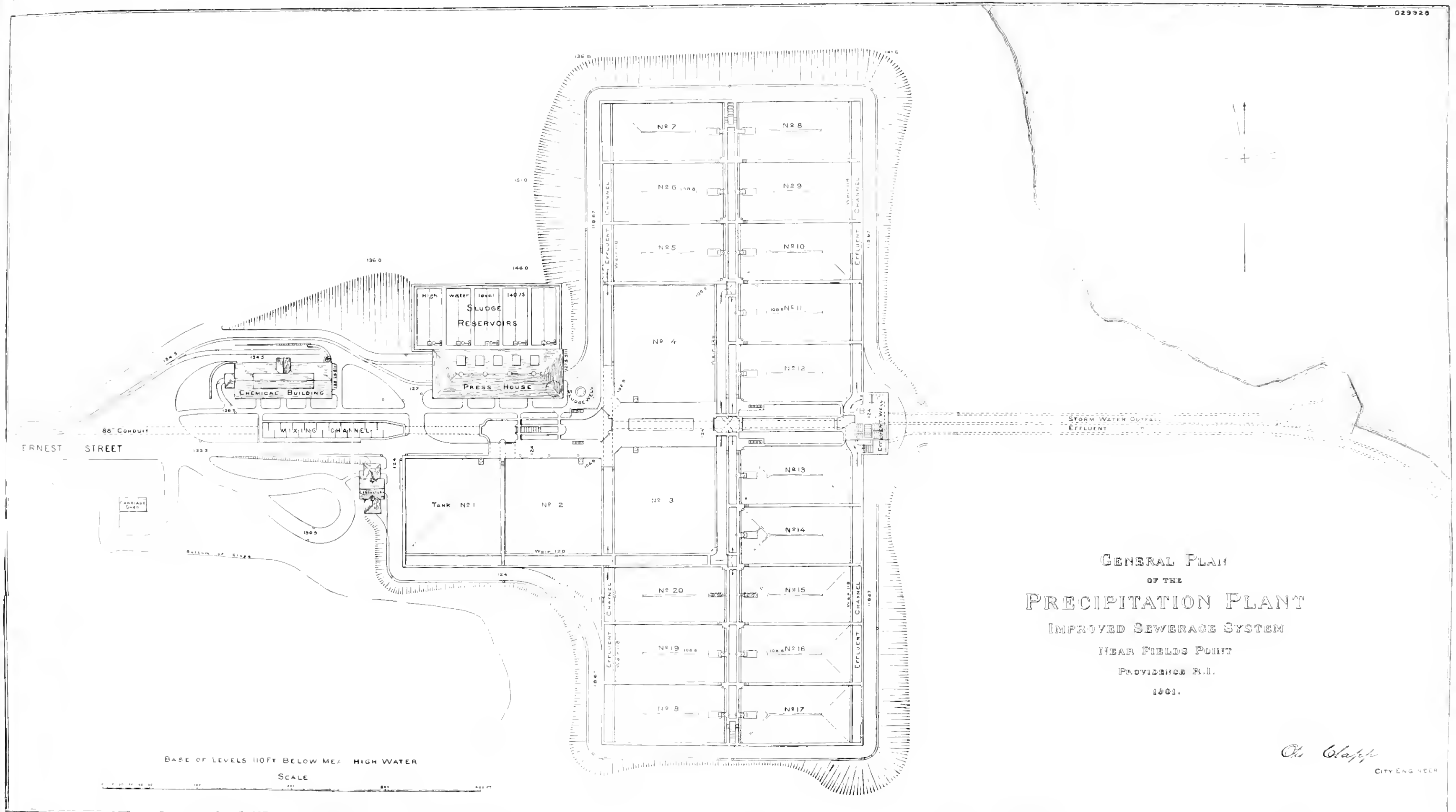
Julius W. Bugbee, had the advantage of 6 years' experience in Worcester, and his work has proved successful from the first.

The cost of the precipitation plant, including everything except original cost of land, has been $309,155.60, and the maintenance will be considerable below the original estimated cost.

The pumping station complete, except land, cost $273,437.24.

Our intercepting sewers have cost $2,967,742.73, and the outlay for land for stations and rights of way has been $141,676, making a total of $3,692,011.57.

The regular system of sewers has cost $3,782,210.43.



GENERAL PLAN
OF THE
PRECIPITATION PLANT
IMPROVED SEWERAGE SYSTEM
NEAR FIELDS POINT
PROVIDENCE R.I.
1901.

Otis Clapp
CITY ENGINEER

THE USE OF THE SEPTIC TANK IN CONNECTION WITH SEWAGE DISPOSAL WORKS.

[Papers and discussion at the meeting of the Sanitary Section of the Boston Society of Civil Engineers held February 3, 1904.*]

By Mr. Frank A. Barbour, Civil Engineer, Boston, Mass.

Any subject is interesting until its merits are settled; and when, on the one hand, it appears that the Massachusetts State Board of Health will not sanction plans involving the use of prolonged sedimentation, and when, on the other hand, we find this feature included as an essential part in a majority of the disposal plants constructed during the past five years and recently recommended by a leading sanitary engineer for use in perhaps the largest sewage purification system yet undertaken in this country, it is apparent that the merits of this process are not yet settled. To add spice to the situation, two different companies have brought suit at a number of places in which claims for proprietary rights are made. Certainly to some of us it has been clearly brought home that the so-called *septic* tank is a live sanitary issue at the present time.

"When is a settling tank not a settling tank?" is an interesting septic conundrum. The answer has been made that the time of holding the sewage is the determining factor, but what this time must be is not yet apparent. It depends upon the strength and age of the sewage, and anywhere from six to twenty-four hours has been set as the optimum period.

With our present knowledge, it is a difficult matter to state when a structure in which the sewage is brought to rest ceases to be a plain settling tank and becomes a so-called septic tank. There is nothing in the design to determine the difference—nothing necessarily in the size, because settling tanks may include provision for mixing and equalizing the flow of manufactural sewage. If the so-called septic tank in contradistinction to a settling tank only exists when the process of liquefaction is a success, then its definition cannot yet be predicated.

Experience has clearly shown that the early claims as to the possible results of liquefaction were exaggerated, and that all tanks into which sewage flows and is brought to such a state of rest that the solids will precipitate will sooner or later accumulate such an amount of sludge as to necessitate emptying. That this is true does not finally condemn the process; it merely limits discussion of its

* Manuscript received March 26, 1904.—Secretary, Ass'n of Eng. Socs.

merits to a consideration of the relative economy and sanitary efficiency of prolonged sedimentation and infrequent discharge of the solid matters, as compared with quick sedimentation, or the application of raw sewage directly to the filters.

It is fair to base the case for these preliminary treatments on their use in connection with some form of filtration—the successful maintenance of which divides itself into two parts—namely, the prevention of clogging of the surface or body of the bed material by suspended solids and the application of the liquid in such doses as to effect purification at the highest possible rates. It is at once apparent that the process of prolonged sedimentation may be likewise considered from two standpoints: first, its effect on the disposition of the solid matters of the sewage; and, secondly, its effect on the liquid portion in making purification possible at higher rates.

Except under the most favorable conditions of soil, it is usually considered to be advisable to remove the suspended matters from the sewage before application to the filters. By whatever method removed these solids are difficult to dispose of, particularly in winter. At Brockton, where the solids are settled out and applied to particular beds, 1850 tons of rakings were handled in 1902, at a cost of about $1500. In winter nothing can be done, and when the thawing process begins with the advent of warm weather the critical period of operation occurs, and there is apt to be considerable odor. It is possible that prolonged sedimentation, even if the tanks require periodic emptying, can be justified in the possibility of holding the solid matters during certain periods of the year. The question is one of relative economy in maintenance and ability to dispose of the staler sludge without nuisance.

At Saratoga, N. Y., there are two periods during which it is especially desirable that the filters be maintained at the point of highest capacity, namely, the summer months, when the population is increased from a normal of 12,000 to about 50,000 by visitors, and the winter, when the temperature falls to an extremely low point. Experience at this plant during the present severe winter has indicated that—aside from whatever liquefaction of the solids may be effected—the ability to avoid the discharge of sludge on the beds during periods of low temperature is of considerable advantage. The time of absorption is much less than in plants handling untreated sewage.

As to the other point of view, from which the process of prolonged sedimentation may be considered, namely, its effect on the liquid portion of the sewage so as to make higher rates of filtration possible, opinions differ. The septic skepticism of the Massachusetts

State Board of Health is largely based on the belief that it is easier to purify fresh sewage than a stale effluent. This, because of the difficulty in effecting nitrification. On the other hand, a prominent engineer recently testified that septic effluent could be purified at rates ten times as great as those possible with untreated sewage, this opinion being based, not so much on the removal of the solids, as on the condition of the organic contents of the effluent.

The speaker believes that by adequate aëration and by application of the liquid to the filters in small doses, and at such rates as to effect good distribution, a stale effluent can be successfully purified.

The anaërobic condition should, so far as possible, be ended before the effluent reaches the filters, and this can be done by properly designed aërators.

In the speaker's experience on six different plants there has been no difficulty in reaching a high degree of purification.

When it comes to comparing the possible rates of filtering stale effluent with those common for untreated sewage, the difficulty lies in the fact that the maximum rates for the latter have not yet been demonstrated. Massachusetts plants are eminently safe and worthy of their reputation, but the distribution systems in use are not so well designed as to reasonably make them a criterion of the maximum rate for untreated sewage. Because rates of 25,000 to 50,000 gallons per acre daily have been the average, is not a proof that higher rates cannot be successfully maintained, and it is very possible that if the same care were taken in the method of dosing, underdraining and general design of filters for fresh sewage as is necessary for the successful handling of a stale effluent, rates more nearly approaching those claimed for the latter would be proved possible.

Within the scope of these remarks but little detailed reference can be made to particular plants, but a few brief statements may be of interest.

In 1899 a tank with a capacity of 140,000 gallons was constructed at Marion, Iowa. It is in one compartment, 63 x 37 x 8 feet, covered with an arched masonry roof. The flow of sewage, as determined by gaugings, equaled about 165,000 gallons daily. This sewage had been emptied into a water course, and suits had been brought against the city by riparian owners. The design included filters, but only the tank was constructed. It was not emptied for more than 2½ years after being put into operation, and has handled the sewage without nuisance and without complaint on the part of those living on the stream. The following analyses of the sewage are taken from a recent paper by Professor Marston:

Total solids	63.20 parts per 100,000
Free Ammonia	1.60 " " 100,000
Albuminoid Ammonia	1.80 " " 100,000

A letter received last week from a city official declares the plant to be an entire success. At all events it has apparently satisfied local conditions.

At the Ohio Soldiers' Home, Sandusky, tanks, in two units of 50,000 gallons capacity each, were put into commission in May, 1903. The sewage amounts to about 100,000 gallons per day, and is somewhat weaker than normal.

Both compartments of the tank were used during the early weeks of operation, but the appearance and odor of the effluent testified to a too prolonged sedimentation, and one unit was thrown out of use. Since the change 62 per cent. of the organic matter of the sewage, as shown by the albuminoid ammonias, has been removed by the tank. The effluent is aërated and automatically applied, in doses of 10,000 gallons, to sand filters. The following figures show analyses of filtrate:

Free Ammonia	0.0052 parts per 100,000
Nitrates	1.80 " " 100,000

In June, 1902, tanks of 1,000,000 gallons capacity, in 4 units, were put in operation at Mansfield, Ohio. Each unit is 52 x 92 feet in plan, the depth varying from 6.5 to 7.5 feet, because of a floating orifice, which maintains a practically uniform discharge at all times, and so equalizes the hourly variation in flow. The sewage ranges in quantity from 700,000 to 1,000,000 gallons per day. All four units are used, and the sedimentation period averages somewhat over twenty-four hours.

The sewage is weaker than average town sewage, the free ammonia varying from 1.5 to 2 parts per 100,000. About 55 per cent. of the organic matter, as shown by albuminoid ammonia, is retained by the tanks; on the basis of the suspended solids 75 per cent. is intercepted.

On September 15, 1903, measurements of scum and deposit showed the former to be less than three inches thick at the maximum point, and in many places only a fraction of an inch, while the deposit ranged from three inches to six inches in thickness. Nothing has been removed from the tanks at any time.

The effluent is passed through cinder contact beds, one and one-quarter acres in area, of which one-quarter of an acre is out of commission at all times. The average rate of operating these beds is about 750,000 gallons per acre. The air space has not decreased perceptibly after the first month.

In August, 1903, tanks of 1,000,000 gallons capacity, in four units, each 51.5 x 91.5 x 8 feet deep, were put into operation at Saratoga, N. Y. The discharge of each tank is over a weir and the inlet is governed by a gate, so that the amount received by each unit or the time of sedimentation may be regulated as desired. The amount of sewage handled has varied from 2,000,000 gallons per day in August, to a minimum of 1,200,000 gallons in November, and then up again to 1,800,000 gallons in January.

The sewage was strong in August, when the contributing population varied from 30,000 to 50,000 people, but in the other months it has been weaker than normal. The following analyses of sample collected November 2d, when the flow equaled about 1,200,000 gallons, indicate the quality of the sewage:

Total solids	67.70	parts	per	100,000
Suspended solids	28.10	"	"	100,000
Free Ammonia	2.1120	"	"	100,000
Total Albuminoid Ammonia	0.5200	"	"	100,000
Suspended " "	0.3150	"	"	100,000
Chlorine	7.94	"	"	100,000

Analyses of the tank effluent collected on same day show the following results of prolonged sedimentation:

Reduction of Organic Matter (basis of total Al. Am.)	45.8	per cent.
" " " " " " Susp. " "	70.2	"
" " " " " " " solids	74.7	"

All samples are collected in portions at intervals throughout the day. About 515,000 pounds of dry solid matter has entered the tanks since operation was begun, and 145,000 pounds of these solids have passed out in the effluent. Measurements made on January 23d, with a gauge similar to that shown in Fowler's "Sewage Works Analysis," show the average thickness of scum to be 16 inches and of deposit also 16 inches. The following figures show the character of the scum and deposit:

	Scum per Cent.	Deposit per Cent.
Moisture	86.69	94.24
Volatile matter	10.12	4.49
Mineral residue	3.19	1.27

The specific gravity of the scum is equal to 0.972, and of the deposit 1.024. From the foregoing figures it appears that there are about 200,000 pounds of dry matter now in the tanks, indicating that about 170,000 pounds, or 40 per cent., of the solids left in the tanks by sedimentation have disappeared. The solids which pass through the tanks, while equal to 30 per cent. of the total in the sewage, are so fine and so decomposed that no visible accumulation

takes place on the beds, except just at the outlets, where a slight deposit, which changes from day to day, sometimes appears. Analyses of this deposit show it to contain from 1.3 to 2 per cent. of nitrogen and from 7.4 to 8.9 per cent. of fats.

The effluent is passed over an aërator and applied to sand filters, each 1 acre in area, in doses of 35,000 gallons, at a rate of 8 cubic feet per second. The following results of the dissolved oxygen test may be interesting:

	Per Cent. of Saturation.
Sewage entering tank	4.3
Effluent before aëration	0.0
Effluent immediately after aëration	70.4
Effluent as applied to filters	40.4

No difficulty has been encountered in effecting nitrification, and the percentage of purification, based on free ammonias, has reached as high as 99.8 per cent.

The solids accumulated most rapidly in the tanks during the first month of operation. From September 1st to December 1st conditions were stationary, but after December 1st an increased rate of accumulation has been evident. The temperature has been so low that the surface of the scum in the tanks is frozen.

The foregoing brief references are all to plants too recently put into operation to furnish data of conclusive value, but to the speaker they indicate that there are possibilities in the process of staling sewage which justify its further use.

Opportunity for engineers to scientifically study the operation of plants designed by them is the thing most needed at the present time. Perhaps through the influence of our Sanitary Section such a standard of maintenance will be established that engineers will be retained at least during the first year of operation. If this were done information establishing the optimum period for different qualities of sewage, the most suitable depth and design of tanks and the most economical and sanitary way of handling the sludge when the tanks require emptying might be forthcoming. In the light of present experience, the speaker believes that for small institutional plants, for plants in which it is desirable that the daily attendance be reduced to a minimum for places where sand is difficult to obtain and filters are expensive, in plants where there is relatively much manufactural waste requiring for its purification mixing with the domestic sewage, and in plants where there are seasonal extremes of quantity and quality of the sewage, or of temperature, the process of prolonged sedimentation *is worthy of consideration.*

BY MR. HARRISON P. EDDY, SUPERINTENDENT OF SEWERS, WORCESTER, MASS.

When the septic tank was first introduced in England and it was found that it did not at once fill up with sludge, many engineers forthwith jumped to the conclusion that the magic properties of this method entirely consumed the solid matter removed from the sewage during its passage through the tank. Opinion on this subject, however, is gradually changing as the facts are more carefully studied.

It is now generally acknowledged that there must be an accumulation of solid matter in the tank, and the question which is now paramount is—how much will this amount to? That there is a very active fermentation going on in the tank is obvious to the most casual observer.

The proportion of suspended matter in sewage varies widely, frequently ranging from 25 to 50 per cent. of the total solids. The first function of the tank is that of sedimentation, resulting in removing from 25 to 50 per cent. of this matter. When the tank is first started and there is no old sludge in it the conditions are very favorable to sedimentation. The sewage is admitted in a continuous stream, which is so gauged that it has ample opportunity to spread over the entire width of the basin, and flows through it without creating a current of sufficient velocity to prevent sedimentation.

The solid matter which finds its way to the bottom of the basin at once begins to decompose. It forms a very fertile nutrient medium in which bacteria multiply rapidly. An average of 45 counts gave in the sludge of a septic tank at Worcester over 12,000,000 bacteria per cubic centimeter, while in the supernatant liquid the number averaged at the same time barely 1,000,000 bacteria per cubic centimeter.

The bacteria which live in the sludge are prolific gas producers, and some of the organic suspended matter of the sewage is transformed by them into gases such as carbon dioxide, marsh gas, nitrogen and hydrogen. This process doubtless accounts for some of the loss in organic matter credited to the septic tank.

The gas thus formed is held mechanically in the sludge until it accumulates to such an extent that it is able to lift the solid matter which is holding it down when it rushes to the surface of the water, and if not again held back by solid matter is liberated into the surrounding atmosphere. For evidence of the truth of this last statement there is no need of chemical analysis if the observer has the misfortune to possess a reasonably sensitive olefactory

organ. The gas carries large quantities of sludge to the surface when it is liberated in this way. Some of the gas is even held by the larger particles of solid matter after it has risen to the surface, and it is thus able to float for some time until perhaps a gust of wind or a shower of rain liberates the gas and it again returns to the bottom of the tank, only to be again raised by a fresh lot of gas. If the weather is fair and there is little wind the solids thus brought to the surface may remain there long enough for quite an accumulation of like matter to take place. If this floating sludge, commonly called scum, is not disturbed, it will interweave in such a manner that the elements will not be able to break it up. It will also become partially impervious to the gas generated under it, so that the gases coming up will be retained, and in this way a thick crust will be formed, which will be strong enough for a man to walk upon with perfect safety.

When the fermentation is active in the tank there is a continuous evolution of gas with a consequent stirring up of the sludge. It is this which accounts to a large extent for the suspended matter in the effluent. For this reason it is wise to provide for a distribution of the sludge which will prevent, as far as possible, the carrying over of the solid matter. This was accomplished to some extent with one of the septic tanks at Worcester. The tank had a cement bottom, at a nearly uniform depth, below the top of the basin throughout its length. Wooden partitions were erected across the basin laterally, dividing it into 4 compartments. These partitions were only just high enough to prevent the sludge from flowing from one compartment into the next. Directly over these partitions were hung wooden partitions extending down from the surface of the water, when the basin was full, to a depth sufficient to prevent the scum from passing from one section to the next. In this way the sludge, when it first comes into the tank, is confined largely to the first section. Practically all of the heavier particles are retained here. The most active fermentation is in this section, and as the sludge is lifted by the gases and the smaller particles fall slowly to the bottom they are taken over into the next section by the current. In this way there is a sort of separating of the different qualities of sludge, and that which is less actively engaged in fermentation is carried down toward the discharge end of the tank. This greatly facilitates the removal of the suspended matter. The scum is also largely held in the first section by the top partitions. The details of this arrangement of partitions are given only to illustrate the

theory. They were temporary in nature and only for experimental purposes.

The experiments just alluded to have been conducted during about 4 years. The tank is 166.66 feet long, 40 feet wide and about 7 feet deep. Its capacity when in operation is 350,000 gallons, allowing for filling once in 24 hours. From June, 1902, until July, 1903, it was in continuous operation at rates ranging from 300,000 gallons to 750,000 gallons per day. Storm water was always excluded. In all, approximately 185,000,000 gallons were passed through the tank in that time. The amount of sludge removed from the tank at the end of the period was 56,250 gallons, containing 65,325 pounds of solid matter. The suspended solids entering the tank, but not passing out with the effluent, amounted to 134,904 pounds. Deducting the solid matter removed from the tank in the form of sludge there were 69,579 pounds of solid matter destroyed. This amounts to 51.65 per cent. of the suspended solids removed from the sewage.

The amount of sludge removed from the basin at the end of this period came to 1.5 cubic yards per 1,000,000 gallons of sewage passed through the tank. This is less than one-half the amount obtained from another experiment, and it is very doubtful if it would be safe to figure on an accumulation so small. It is also doubtful just how far to allow the sludge to acccumulate in the tank on account of the increasing amount of suspended matter carried out with the effluent. If we allow 3 cubic yards per 1,000,000 gallons of sewage, the amount of sludge which would have been produced at Worcester in 1903, had the entire flow of sewage been treated by the septic process, would be 17,028 cubic yards, not exactly in a negligible quantity.

The sludge from the septic tank is a very characteristic material. It is black, usually finely divided, rather heavy and of an extremely offensive odor, unless it has been allowed to undergo very complete decomposition. To run it out onto land in its natural wet condition would make an intolerable nuisance if there were any dwellings nearby or if the plant was near a frequented road. It can be reduced in volume by filter pressing only with great difficulty and at very excessive cost.

After all, even this process has not gotten rid of the sludge, which has always been the cause of serious perplexity with all systems of sewage disposal—sedimentation, chemical precipitation and filtration in all of its different modifications.

BY MR. GEORGE E. BOLLING, CHEMIST, BROCKTON SEWER DEPARTMENT.

At Brockton we conducted a septic-tank experiment during the months of August and September in 1900.

We calculated that the lighter portion of our sewage, which amounts to about 90 per cent. by volume, was being disposed of quite satisfactorily on the intermittent filtration beds, but the other 10 per cent. by volume contains the settlings from the bottom of the receiving reservoir, and the practice has been to discharge this sludge on certain beds set apart for the purpose, each bed receiving a dose every fourth day. The very rapid clogging of the surface, and the expense of cleaning these beds, induced the Commissioners to construct a small experimental septic tank, in order to obtain more light on the subject.

In August, 1900, the solids of the sludge in parts per 100,000 were 294, and about 4 doses could be applied to a bed before clogging it, and a dose of say 90,000 gallons would remain upon the bed 2 days before absorption.

Our experimental tank was patterned after the original septic tank at Exeter, in having a submerged inlet and outlet, and the sewage passing through it being kept at a constant level. The tank was made of wood, 10 feet long, 3 feet wide and about 6 feet deep, lined with galvanized iron, and was of about 1100 gallons capacity. Owing to the sewage flow at the beds not being continuous a storage tank was also provided, from which a uniform flow of sludge was delivered into the septic tank by means of a movable outlet controlled by a float. The results obtained from its use as an open septic tank for the period of 2 months, the time of passage through the tank being 24 hours, are given in the table on opposite page.

AVERAGES BY MONTHS OF ANALYSES OF SLUDGE ENTERING AND OF EFFLUENT ISSUING FROM SEPTIC TANK.

(Parts per 100,000.)

		Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
		Total Residue.			Loss on Ignition.			Free.	Albuminoid.					
		Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.		Total.	Dissolved.	Suspended.		Filtered.	Unfiltered.
First Month.	Sludge	294.45	45.17	249.28	208.07	20.17	187.90	3.2220	4.9262	0.4479	4.4783	10.15	6.75	38.27
	Effluent	68 90	52.22	16.68	37.86	24.72	13.14	4.3000	0.8154	0.5250	0.2904	10.37	6.19	11.55
	Decrease, per cent.	76 60	...	93.31	81.32	...	93.01	...	83.45	...	93.51	...	8.29	69.82
	Increase, per cent.	...	15.61	...	...	22.56	...	33 46	...	17.21				
Second Month.	Sludge	279.28	55.28	224.00	199.82	25.52	174.30	5.1645	5.3569	0.4750	4.8819	11.98	8.14	40.83
	Effluent	77.20	64.52	12.68	42.25	32.28	9.97	6.4075	1.0187	0.6031	0.4156	12.10	6.88	12.84
	Decrease, per cent.	72.36	...	94.34	78.86	...	94.28	...	80.98	...	91.49	...	15.48	68.55
	Increase, per cent.	...	16.71	...	...	26 49	..	24.07	...	26.97				

After 2 weeks' use there was a deposit of 7 inches in the bottom of the tank, and a floating mat of scum 11 inches thick at the inlet end and ½-inch thick at the further end. A brace across the center of the tank, which apparently prevented the scum forming as quickly at the further end, was removed at this time.

At the end of 4 weeks' use the deposit amounted to 8 inches in depth, and the scum was 20 inches thick at the inlet and 6 inches thick at the outlet end.

After 8 weeks' use the deposit was still only 8 inches in depth, while the scum was 30 inches thick at the inlet and 20 inches thick at the outlet end, and tended to clog the slotted outlet pipe.

The tank was then cleaned out and the outlet pipe was to have been lowered and the trial continued, but at this time the Commissioners figured up the cost of cleaning out the tank, and judged that if a sufficiently large tank was constructed to treat all our sludge by the septic method, the cost would be greater than the present system of raking the beds, and decided that the experiment be discontinued.

From the analyses it appeared that during the 8 weeks' period of operation there entered the tank 1345.21 pounds of solids in suspension. Of this amount:

602.39	pounds,	or	44.78	per cent.,	removed on cleaning.
218.33	"	"	16.23	"	went into solution.
83.45	"	"	6.20	"	suspended in effluent.
441.05	"	"	32.79	"	escaped as gas, or is otherwise unaccounted for.

The solids removed from the tank on cleaning presented the following composition:

	Scum.		Deposit.	
Water	86.74	per cent.	92.49	per cent.
Organic Matter	9.38	"	5.55	"
Mineral "	3.88	"	1.96	"
	100.00	"	100.00	"

The specific gravity of the scum was 0.988, and of the deposit 1.032. After the pile of material taken from the tank had been exposed for a week an analysis, made to determine its value as a fertilizer, figured up between $3 and $4 a ton. It contained nitrogen to the amount of 1.96 per cent.

It was a matter of regret that the experiments were not carried further, so as to watch the effects of varying rates of flow through the tank and to obtain some data concerning filtration of the septic effluent. Our experiment was not carried into the winter, but was conducted at a time most favorable to the operation of the septic tank. The experiment was short, but impressed us that sludge alone was too stiff a proposition for the septic tank to deal with.

BY MR. ANDREW J. GAVETT, PLAINFIELD, N. J.

The city of Plainfield, with a population of about 18,000, is situated 24 miles from New York City. A sewerage system was constructed by the city in 1895, separate sewers being used for storm water and for sewage. The sewage was originally discharged on intermittent sand filters; but, in 1901, septic tanks and contact beds were constructed, and since that time the sewage has been treated by the new works. There are now 1775 sewer connections, 275 having been added during the past year, and the flow of sewage has nearly doubled since the new purification works were started, being now about 800,000 gallons per day, which increases to over 1,000,000 gallons at times of high-ground water. It is proposed to examine and repair some of the sewers in the wet district as soon as the weather will permit, and plans for enlarging the disposal plant are also under consideration.

The disposal plant consists of 2 septic tanks, side by side, under one roof, and a double set of bacterial contact beds, 8 in all; the new works are located 200 feet from the nearest streets, and the sewage does not appear on the surface until discharged into the brook.

The septic tanks are each about 50 by 100 feet and 7 feet deep, the water rising 6 feet above the bottom. They contain about 450,000 gallons of sewage, and with the average flow the sewage is 13 hours in passing through the tanks. After leaving the tanks the effluent passes over a weir in a thin sheet and falls into a channel, the weir and channel extending the full length of each tank, 100 feet in all.

The contact beds are in 2 sets of 4 each, the first set being 5.42 feet higher than the second, each bed having an area of 9750 square feet and a total depth of 5 feet. In the upper set of beds the working material is trap rock, $3\frac{1}{2}$ feet deep, varying in size from $\frac{1}{4}$ to $1\frac{1}{2}$ inches, and in the lower set slag is used in some beds and cinders in others, somewhat smaller in size than the stone in the upper beds. The bottom 6 inches and the top 12 inches of all the beds are composed of $2\frac{1}{2}$-inch stone; in the former are the horseshoe drain tiles and in the top foot of the material (into which the sewage is not allowed to rise) distributing pipes are laid, consisting of vitrified sewer pipes from 3 to 12 inches in diameter, laid with open joints, except the 12-inch pipes, which are cemented. The partially purified sewage passes continuously from the septic tank to a gate chamber at the intersection of the division walls of the first or upper contact beds. Here it is diverted by wooden gates to each of the 4 beds in succession. After flowing into one bed for 2 hours the sewage is

turned to the next bed, each of the 4 receiving the flow in turn. The sewage in the first bed, after being retained for 2 hours, is drawn off, and passes through a pipe to the gate chamber of the second set of contact beds, where the same process is repeated. After the period of rest in the second set of beds, the effluent is turned into the brook. Each bed receives a rest of 2 hours before each filling, and 2 hours each are allowed for filling and for emptying; the material in the beds is sufficiently coarse to allow the air to be drawn down to the bottom of the beds at each emptying.

The sludge accumulates very slowly on the bottom of the tanks, but the scum gathers more rapidly, and is removed, about three times a year, through the sludge pipes to a sand filter bed, after as much as possible of the clearer middle water has been run off onto other beds, separate valves and pipes being provided for this purpose. When the sludge is running from the tanks a deodorant is added, either strong limewater or permanganate of potash, the latter being preferred.

During one period of 5 months, including winter weather, the scum increased about 1.25 feet, making, in both tanks, 463 cubic yards; after this was sufficiently dried to be piled up it measured 130 cubic yards. In the following warmer 5 months the scum amounted to about 1 foot in average depth. These figures are only a rough approximation, as it is difficult to measure the varying thickness of scum in the septic tanks. The flow of sewage during this time was about 650,000 gallons per day, this quantity being at times much increased by ground water.

The sludge is allowed to dry out on the sand beds and is used as a fertilizer on them and on other parts of the property, on which good crops of sweet and yellow corn are raised.

The temperature of the sewage and effluent is nearly constant; recently, when the temperature of the air was 10° below zero, that of the sewage was 56°, the effluent from the septic tank 55° and the final effluent 53°. Since then, during a time of much ground water, the temperature of the final effluent fell to 49°, but afterward returned to the normal temperature.

The effluent from the works has been satisfactory, and there have been no complaints from the adjoining owners or residents since the present works were installed. The New Jersey State Sewerage Commission, in its report written in 1902, states that "87 per cent. of the bacteria were removed and the putrescible matter completely disappeared."

Analyses in the spring of 1903, by Mr. L. R. Thurlow, Health Officer of the Plainfield Board of Health, gave the bacterial

efficiency of the septic tanks as 55 per cent., and of the whole plant as 87 per cent.; the efficiency of the septic tanks, as shown by the removal of albuminoid ammonia, was 38 per cent., and by oxygen consumed 44 per cent. Mr. Thurlow gives the efficiency of the whole plant as 90 per cent. by the removal of albuminoid ammonia, and 86 per cent. by oxygen consumed. He believes that the plant is doing better work now.

The works are operated by hand, requiring the services of 1 day man and 1 night man, who are paid $67.50 and $45 per month, respectively; additional labor costs about $15 per month.

The cost of the plant, exclusive of land and engineering services, was $38,750.

BY MR. R. WINTHROP PRATT, ENGINEER, OHIO STATE BOARD OF HEALTH.

In most localities in the State of Ohio the geological conditions are such that no sand or gravel, suitable for sewage purification, can be obtained without transporting it over long distances, making the cost prohibitive.

To these conditions is largely due the fact that, since about the year 1897, when the septic tank began to be so much in evidence, nearly every proposed sewage purification scheme has included a septic tank as a means for reducing the area of necessary filtering material. The Ohio State Board of Health has in some cases approved these plans just as they were submitted, and, in other cases, where a high degree of purification was necessary, has required the addition of a certain amount of filtering material in order not to place too much dependence upon favorable action in the septic tank.

There are now in use in this State, by cities, villages and public institutions, 26 sewage purification works, while 18 more will probably be in use in the near future. Of the 26 plants now in use 5 cities and villages, 3 public institutions and 1 manufacturing establishment use the septic tank; and of the 18 cities and villages having proposed plans 14 will use it.

Nearly all of the systems now in use have a storage or flush tank of some kind, in which more or less septic action occurs, but those here mentioned are all designed strictly as septic tanks, and their construction permits of obtaining full benefit, according to theory, from whatever favorable bacteriological action may take place in them.

In no cases are sufficient chemical and bacteriological data available to accurately judge of the efficiency of these tanks, but they have all been inspected from time to time, and a few chemical

samples have been taken. As far as can be learned, the tanks continue in use for from 1 to 2 years without decreasing more than 25 per cent. in capacity. The "matte" formed on the surface varies from nothing to 1 foot in thickness. Both surface and bottom accumulations appear to remain fairly constant in volume in each case as long as the conditions of operation remain the same.

The odor from the tanks is often no more objectionable, if as much so, than that from the average settling tank; but in some cases very offensive odors are created.

We have then little uniformity in the degree of usefulness of the septic tank, and this strongly emphasizes the fact that not only should all conditions be carefully studied and made as favorable as possible before designing a tank, but that after the tank is in use it should be carefully watched and tested, in order to determine the most efficient mode of operation.

THE EAST CLEVELAND TANK.

East Cleveland is a residential suburb of the city of Cleveland, having a separate local government. The population has increased from 1000 in 1895 to 6000 at the present time. In 1898 and 1899 a separate system of sewerage was built and designed to drain nearly the whole town. The domestic sewers are provided with underdrains, but, nevertheless, there is at times a large amount of leakage into them; this leakage is probably increased on account of the storm sewers being laid above the domestic sewers. There are now 40 miles of domestic sewers which receive the sewage of over 5000 people, but no manufacturing wastes. The dry-weather flow is from 300,000 to 400,000 gallons per day, but increases to more than 1,000,000 gallons in wet weather.

A system of sewage purification was installed in 1899 according to the plans of the City Wastes Disposal Company, of New York, which plans provided for the continuous filtration of the sewage; first, downward through egg-sized slag; second, upward through similar material; and third, downward through "aërators" or filters of small-sized "pea" coke. All filters receive continuous forced aëration furnished from a blower in the pumping station. The rate of application to the first filter was 10,000,000 gallons per acre per day, and the rate through the entire area of filtering material was 660,000 gallons per acre per day.

This system was used for about 2 years, but it was found that the filtering material needed frequent cleaning at great expense, due, it is said, to the increase in the volume of sewage and to the clay and other irreducible matter reaching the works in wet weather.

Therefore, late in 1901, the plant was increased along the same lines, and in addition a septic tank was built for preliminary treatment of the sewage. This tank is of brick masonry, 24 x 87 feet and 11 feet deep. It is covered by a wooden pitched roof, the top of which is 9 feet above the level of the sewage. Sewage enters at mid-depth through openings, 6 inches square, equally spaced across one end, and is drawn off through horizontal slots, 12 inches by 2 inches, equally spaced across the other end. The tank holds 170,000 gallons, or 10 hours' ordinary flow. The horizontal velocity is 1.8 inches per minute.

After one year's use the tank was said to contain a scum less than 2 inches thick, while the solid matter at the bottom was 2 feet deep. It has now been used about 1 year since cleaning, and contains about the same amount of material as at the end of the first year.

Chemical analyses of composite samples collected by the attendant in April, 1903, show no marked changes in the composition of the sewage during its passage through the tank.

However, since the enlargement of the works and the introduction of this tank, it has been necessary to wash the filtering material less frequently, and the effluent from the works is clear and odorless and produces no nuisance. A few chemical analyses have been made of this effluent, which show it to be well purified.

The odor from the septic sewage, as it flows onto the filters, combined with the odor from the clogged filtering material, is offensive, and causes more or less complaint on the part of the nearest residents.

The cost of the tank was about $3000, while that of the entire plant was $66,000. The annual cost of maintenance is $3000.

THE KENTON TANK.

The system of sewage purification at Kenton, also designed by the City Wastes Disposal Co., is septic treatment, followed by intermittent filtration through "pea" coke covered by broken stone.

Though Kenton has a population of 8000, the sewage of only 400 people is conveyed to the purification works. The daily flow is about 25,000 gallons, all of which is domestic sewage, except the surface water which is admitted through 2 catch basins.

The septic tank is 28 feet long, 16 feet wide and 6 feet deep, holds 21,000 gallons and is covered by a wooden house. Sewage first passes through a small grit chamber and then enters the tank 2 feet below the surface and is drawn off through small openings, at the other end, at the same depth. It then enters one of the 3

"dosing" filters, which are flush tanks, filled with broken stone, and which discharge intermittently onto the filter beds.

These beds consist of 3 parallel open tanks, each 10 x 100 feet, and filled with a layer of "pea" coke 18 inches deep at the upper end and 4 inches deep at the lower end. The coke is covered with broken stone. The beds have a sharp slope away from the septic tank, so that each dose of sewage flows through them laterally with a kind of wave motion; the idea being to obtain as much aëration as possible and at the same time keep the sewage from appearing on the surface of the filters.

The septic tank is divided longitudinally, so that one-half can be used. The whole tank, however, has been in use ever since the plant was first operated in June, 1902, thus making the septic period from 20 to 24 hours. There was, after 15 months of operation, about 1 foot of sludge in the bottom of the tank and no scum whatever on the surface. However, when storm water is brought in by the sewers a scum quickly forms, but soon disappears when the flow of storm water ceases. It has not yet been necessary to clean the tanks.

Very little odor can be noticed around the plant, and I found, upon entering the house over the tank, after it had been locked for several weeks, that the odor inside was not in the least offensive; in fact, it was much less than that arising from any settling tank that I can recall.

There is no doubt that the tank is successful as a sludge destroyer, but the subsequent treatment has not yet been studied sufficiently by the writer to justify a definite statement as to its efficiency.

THE MANSFIELD TANK.

The largest system of septic tanks and contact beds in the State of Ohio is located at Mansfield, and has been in operation about 2 years.

Mansfield has a population of about 20,000, but only about 9000 are connected with the sewers. A considerable portion of the sewers were built some years ago and received much surface and ground water. An overflow, however, is placed in the trunk line, so that not more than 1,000,000 gallons per day can reach the purification works, and this is the average amount treated. As would be expected, sewage under these conditions is quite weak. The main sewer discharges into a grit chamber at the pumping station, where the sewage is screened and pumped continuously to the septic

tanks, from which it is drawn off at a point about 3 feet below the surface.

There are 4 tanks, having a total capacity of 1,000,000 gallons, or about 24 hours' flow, and all 4 are used. By means of floating orifices the discharge from the tanks is kept constant, regardless of the flow into them. This may cause a daily fluctuation in the surface of the liquid in the tanks of about 6 inches.

Aëration of the septic effluent is obtained: first, by its drop into a collecting channel; and, second, by its passage over aërating steps.

The aërated sewage is then applied through automatic apparatus to contact beds, 5 in number, each ¼ acre in area; and the effluent from these beds is discharged into a small stream.

The plant is well removed from any dwellings, and the septic tank is ventilated into the stack at the pumping station. There is no objectionable odor around the plant. One of the tanks, after 1½ years' use, was drawn off and only a few inches of deposit found in the bottom. No surface scum has formed to any extent in any of these tanks.

The final effluent appears clear and odorless, and tests have shown that the entire process removes from 80 to 90 per cent. of the organic matter, as shown by the albuminoid ammonia and oxygen consumed, and from 98 to 99 per cent. of the bacteria.

This plant, as well as the ones at Trumbull County Infirmary and Soldiers' Home at Sandusky, was designed by Snow & Barbour, of Boston.

THE TANK AT SOLDIERS' AND SAILORS' HOME, SANDUSKY.

The population of this institution is 1400 to 1500, and the quantity of sewage is about 100,000 gallons per day. The sewage is strong.

There are 2 septic tanks, each 26 x 40 feet and 7 feet deep; either one or both can be used. When 1 only is used sewage remains in the tank 12 hours, and when 2 are used it remains 24 hours.

After passing through a grit chamber and screen the sewage enters the tank 3 feet below the surface and leaves at the same depth at the other end. It is then aërated by passing through about 100 feet of galvanized iron gutter about 2 inches deep, from which it overflows in thin streams or sheets and is conveyed into a flush tank.

The flush tank discharges automatically upon intermittent sand filtration beds about 1¼ acres in extent. The sand used in these

beds is about 4 feet deep and of very favorable size and quality for sewage purification.

The tank has been in operation some 8 or 9 months. A heavy scum of a foot or more has formed at the surface and there is more or less of a deposit at the bottom. The tanks have not been cleaned, however. At the beginning both tanks were used, but the septic effluent proved to be so offensive that it was objectionable to the occupants of houses 600 to 1000 feet distant. One of the tanks, therefore, was cut out of service, and since then the odor of the septic sewage has been less objectionable.

The septic tank effluent contains much finely divided matter, which is deposited in the aërating gutters, and has to be removed frequently. Originally a strainer of broken stone was used before the sewage entered the flush tank, but this strainer became so quickly clogged that its use has been discontinued.

The final effluent from the sand filters has been well nitrified and of very satisfactory character.

TANK AT TRUMBULL COUNTY INFIRMARY, NEAR WARREN.

This institution has a population of about 100. The sewage is purified by septic tank and intermittent filtration through coke. The tank is 15 feet long, 5 feet wide and 5 feet deep, and holds 3000 gallons, or a little more than 1 day's flow. There is no screen of any kind at entrance to the tank. The sewage enters and leaves a short distance below the surface. The tank effluent, after passing over aërating steps, is collected in a reservoir of 4000 gallons capacity, from which it is pumped daily to the coke beds.

These beds contain 4½ feet of fine coke, and the average amount of sewage treated by them is 60,000 gallons per acre per day, applied daily, in doses of 2500 gallons, lasting about 1 hour. The effluent appears in the underdrains in about 30 minutes after the sewage is applied. It is clear and odorless, and analyses have shown it to be well purified.

The sewage of this institution is unusually dilute, due to leakage, which at times is so great as to necessitate the discharge of raw sewage directly into a small stream.

During its 4½ years of operation this septic tank has been cleaned but once. The sludge in the bottom retains a constant depth of about 1 foot and the scum is 3 or 4 inches thick. The long septic period and subsequent storage in the reservoir does not seem to prevent satisfactory purification.

The odor is very strong, but is largely confined to the small wooden pump house over the tanks, which is ventilated into the

stack at the boiler house. The iron of the pump has been attacked by gases from the tank. This system of ventilation, however, enables the tank to be located near the institution buildings without causing a nuisance.

OTHER TANKS.

The shops of the Lake Shore and Michigan Southern Railroad employ 500 hands, and are located in the center of the village of Collinwood.

A system of sewage purification, consisting of septic tank and coke contact beds, was constructed in 1902. Both tank and contact beds are covered, although trapdoors are placed over the latter and are usually kept open. No definite information is available any more than to say that it apparently purifies the sewage well enough to avoid polluting the small stream into which the effluent is discharged, and that no objectionable odors are complained of either by the employees of the shops or by occupants of houses a few hundred feet distant. It is understood that no cleaning of either tank or contact beds has been necessary during its 18 months or more of service.

Tanks are also now in operation at Delaware and Westerville, but at these places the works have been in but a short time and accommodate only a few hundred people.

It may be mentioned in closing that the city of Columbus contemplates making experiments on the septic tank and other methods of sewage purification on a larger scale than has ever before been done. The results of these experiments, if made, in addition to helping solve the sewage disposal problem at Columbus, will be of great value and interest to engineers and sanitarians in general.

BY MR. X. H. GOODNOUGH, CHIEF ENGINEER, MASSACHUSETTS STATE BOARD OF HEALTH.

The septic tank, as so described, was first used at Exeter, England, and the results of its early operation were given to the public about 7 years ago.

The results of the early operation of this tank appeared to show that, by allowing sewage to flow slowly through a closed tank, kept full at all times, for a period of from 24 to 36 hours, the solid matters in the sewage became liquefied, and either went into solution or remained in suspension in an extremely finely divided state. It also appeared that much organic matter went off in the form of gas, and that very little solid matter or sludge accumulated in the

tank. By the use of this tank it appeared at first that the sludge problem was practically eliminated, and the sewage remaining was weaker than the original in organic matter, contained little or no coarse matter in suspension, and could be purified more rapidly than ordinary sewage by subsequent filtration.

The announcement of the results of the operation of this tank at Exeter created widespread interest, and with the announcement of the results of experiments upon certain forms of rapid filtration of sewage, which appeared at about the same time, greatly stimulated the investigation of methods of sewage purification.

The septic tank was not claimed, by those who first employed it, to be, by itself, a means of sewage purification. It is a preliminary process, which it was claimed could be advantageously employed in connection with sewage purification works. It is essential to keep this in mind, since, even at the present day, the septic tank is sometimes considered to be by itself a complete means of purifying sewage.

It is not my intention to refer, except in a general way, to the experiments made at Lawrence by the State Board of Health, which have been carried on under the direction of Mr. Clark, who will present a summary of these results; but attention having been called to the fact that the septic tank has not been employed to any considerable extent in connection with sewage disposal works in Massachusetts, some of the reasons why its use has not become more general may be of interest. Only 1 septic tank has been used in connection with the sewage disposal works of any city or town in Massachusetts, and the use of this tank as a septic tank has been abandoned. There are several reasons why the use of the septic tank has not become more general here, since many works using this process have been constructed in other States and in Europe.

When the results of the operation of the Exeter tank were first announced it was obviously necessary, before using this device in practice, to first test its operation under the conditions existing in this country, and with this object experiments upon the operation of septic tanks were begun at Lawrence. The results of these experiments and of experience elsewhere soon gave evidence that there was a great variation in the results obtained from this method of treating sewage in different places and at different times, and that there were some other troublesome features connected with this form of treatment.

In some cases the results were very similar to those first announced at Exeter; in others, the results were unsatisfactory, and the sewage was brought into such a condition, after passing through

the tank, that it was difficult to purify it satisfactorily by a subsequent filtration. Moreover, experience in the operation of septic tanks showed that in many cases sludge accumulated within them more or less rapidly and that the sludge problem was not eliminated. Sludge from such tanks, moreover, has been found far more offensive in some cases than that from ordinary settling tanks. The fact was discovered that sewage was in many cases rendered extremely offensive after passing through a septic tank,—a condition which it is very desirable to avoid at a sewage disposal works.

There is no sure way of determining beforehand what results can be obtained in the treatment of the sewage of a given town by means of the septic tank—showing the great importance, before using this method of treating sewage, of making adequate investigation by means of experiments to determine the results that are likely to follow its use.

There are other important reasons also why the septic tank has not come into general use in this State.

The early investigations upon the purification of sewage by intermittent filtration showed that a well-purified effluent could be obtained by filtering sewage through sand at rates ranging in some cases as high as 100,000 gallons per acre per day and an excellent effluent produced, and the results of experience in the operation of numerous sewage purification works built on the lines indicated by these investigations have shown at many places during a period of many years that well-purified effluents can be obtained with sewage from any of our cities and towns by following the experience furnished by the early experiments at Lawrence and the actual operation of these works.

The experiments upon the purification of septic tank effluents have not given such favorable results as are obtained in actual practice by intermittent filtration. Areas of sand and gravel well adapted for the purification of sewage by intermittent filtration are generally easily available in this State, and the cost of the preparation of sufficient areas for the purification of sewage by intermittent filtration is not generally so large as to make it important to attempt to reduce the cost of the works by the employment of the septic tank. In nearly all, if not all, the cases in which sewage purification works have been constructed in this State, the cost of installation and operation has probably been less than it would have been had a preliminary treatment by the septic tank been employed, while the resulting effluent is probably of better quality than would have been obtained by the use of the septic tank.

Under these circumstances the use of the septic tank has not

become extensive. It may be added that in the only case in which the septic tank has been employed on a comparatively large scale in connection with the works for purifying the sewage of a city or town, sludge accumulated rapidly in the tank. During much of the time when this tank was operated as a septic tank the sewage was diverted into the river and the operation of this septic tank was a failure. The tank is, however, a useful adjunct to the works as a storage reservoir for the night flow of sewage.

The principal experiment by the State Board of Health upon the use of the septic tank—that at Andover—has also given unsatisfactory results in several important respects, chief of which is the fact that the effluent from this tank has not been purified efficiently by subsequent filtration.

So far as the experience in this State goes, then the principal experiment upon the use of a septic tank at Andover has given unsatisfactory results, and as the only case in which the septic tank has been actually employed for the disposal of sewage it was a distinct failure.

While the septic tank has not been a success, as operated in this State, its possibilities do not as yet appear to have been exhausted, and it may be that, in connection with some kinds of sewage, especially those greatly affected by manufacturing waste, its use may be found of advantage.

The septic tank was patented by those who first employed it at Exeter, and other patents upon sewage disposal claim to cover it in this country. Much misunderstanding exists as to the nature of the process and the methods of producing septic action, and it would probably be difficult to determine in some cases whether a given tank is a septic tank or not. In some cases towns and corporations have already paid small royalties to persons claiming patents covering tanks of various kinds employed at sewage disposal works, and claims have been entered in cases of other works where it would seem that by no stretch of its present definition could the tank used be called a septic tank. In some cases these settlements have been deemed good business, since the amount asked for has been much less than would be necessary to contest the case in court; but in at least one case, I am informed, a local authority which had settled with one such claimant for a small sum has already been confronted with the claim of another. Some of these cases are actually already on trial, so that it is likely that before very long something more definite may be known as to the court's opinion of these claims. The claimants of septic tank patents have even entered claims for royal-

ties from places having sewage reservoirs used for the storage of the night flow of sewage in order to avoid pumping at night; but these claims have not thus far been pressed in the courts.

BY DR. DOUGLAS C. MORIARTA, SARATOGA SPRINGS, N. Y.

I came here to-night, Mr. Chairman, to listen and learn all about septic tanks, and not to discuss them. My practical experience with them is *nil*. I can, however, with your indulgence, give you my experience with a sewage disposal system which involves a retention tank; though if I were to confine my remarks to discussing the septic tank *per se* I would be able to say but little.

Our proposition at Saratoga was a peculiar one, in that the sewers received storm water and surface water, which of necessity had to be separated from the sewage. This has been accomplished, and the sewage now runs by gravity to a pumping station, and is there raised into several retention tanks. Here the sewage remains for several hours, when it passes into an aërator, then into the dosing tanks and onto the filter beds.

The results of this treatment, from our standpoint, have been very satisfactory; that is, we have no objectionable odor, and the effluent after leaving the contact beds is satisfactory to the State Board of Health. The quantity of sewage that we care for daily is approximately 2,000,000 gallons. As I have said, the sewage runs into the large tank and from there into the aërator. In this apparatus it comes up from the center like a fountain, and is spread out into a thin sheet on a disk of iron, having a conformation not unlike an umbrella opened. After being aërated, it goes to the dosing tank, which has a capacity of 50,000 gallons. This tank is provided with an automatic apparatus, which can be so adjusted as to discharge its contents on four different beds consecutively.

Concerning the value of the sedimentation or retention in the tanks, I hardly know what to say after listening to the remarks of your experts on this subject; because our plant has only been in operation since July, and thus far we have had no occasion to empty it, nor are we annoyed in any way from it, and our chemist informs us that we are having a marked liquefaction of the sludge. At the aërator there is a slight odor, but not at all marked, and when the sewage is on the beds it is even less. In the immediate neighborhood are two residences; thus far we have had no complaints. If we ever have to empty our retention tanks and it acts as those described by the authors of your interesting papers, we will probably have something to say on this subject when we meet again.

A feature which may be of interest is the operation of our filter beds during the present cold winter. We have never experienced a winter in our locality that has been as cold as this within ten or twelve degrees. The beds were nicely iced over and have worked finely. For a time the size of the doses on the beds was increased to 100,000 gallons; the additional heat in this quantity of sewage was sufficient to operate the beds without difficulty.

As I have said, the effluent is satisfactory to the State Board of Health, so we have had no trouble in that particular way.

Another feature in the minds of the Commission is the attractiveness of our plant; this is in a measure due to the arrangement of the beds, their location and their grading and care. Our disposal plant is really quite a point of interest in our village.

We have twenty-one beds, and of these two are prepared for sludge. So far it has only required two or three men and one horse to care for them, which is much less than we anticipated.

BY MR. HARRY W. CLARK, CHEMIST, MASSACHUSETTS STATE BOARD OF HEALTH.

I can add very little to this septic tank discussion other than a recapitulation of the Lawrence Experimental Station work.

The problem is one that many of us have been trying to solve during the past 6 or 7 years, and a great variety of opinion in regard to the value or the utility of septic tanks is expressed by different investigators along this line, and widely different results appear to have been given by septic tanks at different places. I suppose there is no doubt, if we read correctly the current English sanitary journals, that, while all that was claimed for the septic tank at first is not now believed in, yet the majority of English sewage experts still believe that a septic tank is a valuable adjunct to most filtration plants. Anything that will aid in decreasing the area necessary for filtration appeals to them strongly, this being so, I presume, on account of the scarcity of cheap sandy land, the cost of construction of artificial filters and the cost of operation of sewage farms. I do not think, however, that Mr. Cameron, who installed the septic tank at Exeter and started us all on these tank investigations, has ever claimed that the tank would destroy sludge to such an extent as some of the latter advocates of the system claim. If you read his testimony before the Royal Commission on Sewage Disposal you will find him frankly acknowledging that the tank accumulates sludge. In fact, after 2 years' use, 40 per cent. of the tank's capacity was so filled. Mr. Cameron stated, however, that this was only about one-ninth as much as would have accumulated if the

sludge from chemically precipitating a like volume of sewage had been allowed to accumulate. This seems a pretty strong statement in regard to sludge destruction, but he modifies it, apparently unwittingly, by the further statement that much of the fine matter in suspension in the sewage passes away in the tank effluent. As a guess I should say that if the fine sediment had been measured it would account for a considerable portion of the non-accumulating sludge. It does not follow, however, that because the septic tank appeals to them, or is of value to them, that it would necessarily be of great value generally to us in New England even if as successful in destroying sludge as its most ardent advocates have claimed, although, of course, there are many sections of the country where it would be, the difference being the different conditions in regard to available sand areas, etc., prevailing here. It would certainly be of great advantage in some places, such as Worcester, for instance, if it could or would destroy such a large percentage of suspended organic matter as some experiments and installations upon a fairly large scale have seemed to show judging from the published results.

During the past 6 years we have operated, in pursuit of different investigations, 5 or 6 different septic tanks at the Lawrence Experiment Station. The oldest one, known as Septic Tank A, has received regular station sewage for something more than 6 years. This is a small wooden tank, with a capacity of only about 250 gallons. I do not think, however, that the value of the results obtained from it, or by its use, is any way affected by the fact that it is of small instead of great capacity. I see no reason why the relation of sludge destroyed to that entering should not be the same as with a larger tank if the sewage is of the same quality. Looking over the results obtained from the use of this tank during its period of operation, I find that the average sewage entering has 4.49 parts of free ammonia and 0.80 of a part of albuminoid ammonia. That is, it has been a sewage considerably stronger than the average sewage reaching filtration areas in Massachusetts. The effluent of the tank has had on an average of 4.45 parts free ammonia and 0.39 of a part of albuminoid ammonia; that is, during the 6 years of operation slightly more than 50 per cent. of the albuminoid ammonia of the sewage entering the tank has not appeared in its effluent. It is a fact, however, that the work of the tank has been deteriorating year by year during the past 5 years, although its second year of operation gave better results than the first year. In 1899, 62 per cent. of the albuminoid ammonia of the entering sewage did not appear in the effluent; in 1900, 60 per cent.; in 1901, 51 per cent.;

in 1902, 39 per cent., and in 1903, 35 per cent. One reason for this deterioration is undoubtedly due to the fact that the capacity of the tank has decreased owing to the increase of the sludge within it, and, therefore, the volume of sewage applied has passed through the tank in a shorter number of hours, daily giving less chance for sedimentation to occur. The percentage removal of nitrogenous organic matter in suspension in the sewage entering this tank, as shown by albuminoid determination, has decreased steadily from 85 per cent. to about 50 per cent. in the past 6 years. No sludge has ever been removed from the tank, and at the end of 1903 about 40 per cent. of its capacity is filled with it. The actual solid matter removed from the sewage by the tank, as shown by determination of the solids of the applied sewage and effluent, amounted to 22 per cent. in 1902, and 29 per cent. in 1903. The combustible organic matters removed in 1902 amounted to 35 per cent., and in 1903 to 45 per cent., and there were only about 7 parts of solids in suspension in the effluent of the tank in 1903 compared with over 20 parts in the sewage entering.

The Kjeldahl determinations made upon the sewage entering and in the effluent from Septic Tank A during the year 1903 show a removal of approximately 50 per cent. of organic matter against 34 per cent. as shown, as I have stated, by the albuminoid ammonia determinations.

A much larger tank was operated by the Board at Andover for a period of rather more than 4 years, this being a wooden tank, with a capacity of 9000 gallons, the sewage being approximately 15 to 18 hours in passing through this tank. The results in regard to the removal of organic matter for the entire period were about the same as with the smaller tank, namely, an average of about 47 per cent., as shown by the determinations of albuminoid ammonia, in the sewage entering and the effluent from the tank. This tank was operated without the removal of sludge, and at the end of the period of operation about 20 per cent. of the capacity of the tank was filled with the accumulated matters. The sewage entering this tank was very strong, averaging 7.5 parts free ammonia and 1.3 albuminoid ammonia, and the effluent from the tank averaged 7.1 parts free ammonia and 0.69 of a part albuminoid ammonia. The albuminoid ammonia in suspension of the sewage entering the tank averaged about 0.55 of a part, while that of the effluent was only 0.19 of a part, a removal of about 65 per cent. This tank was doing as good work at the end of its period of operation as at the beginning as far as removal of sludge was concerned.

During the past year a septic tank, known as Septic Tank E,

has been in operation at Lawrence, it seemed to us, owing to many published reports in regard to the large amount of organic matter removed by the operation of some septic tanks, that the character of the water supply in these different localities, or the ground water entering the sewers, might have some effect upon this removal. That is, it was thought that where a particularly hard water was in use, or hard water entered the sewers, a species of chemical precipitation might occur in the tank owing to the passing out of solution of some of the mineral salts, causing the hardness, while the sewage was undergoing tank action. Therefore, the sewage entering this septic tank was made very hard by the addition of such mineral salts as we find in hard waters—lime, magnesia, chlorides, etc. While some such action as we expected occurred, the principal result from this tank was to explain in a way the difference in the character or strength of the odor of septic tank effluents. For instance, the effluent from our Septic Tank A, at Lawrence, while always having a considerable odor, is not particularly offensive. The effluent of this tank, however, was exceedingly offensive, and was caused by the generation or liberation of sulphureted hydrogen from the sewage, this being due to the decomposition of the sulphates added to make the sewage hard. The gases set free from Septic Tank A upon analyses have never shown any sulphureted hydrogen, but there was a large amount in the effluent of this tank. You have all read, of course, of the disputes as to whether septic sewage is ill-smelling or not, and naturally, no doubt, it varies very much at different places, due to some such local reason as this experiment might indicate. Mr. Cameron, in the testimony already referred to, stated that in his opinion the difference was due to time of passage, but this cannot, I believe, account for all discrepancies on the odor discussion.

Another experiment was made upon the treatment of sludge liquor in a septic tank. It seemed probable, from long-continued observations and experiments, that while the passage of sewage through a septic tank may in some instances make the sewage more easily purified upon filters after tank action, still this is not a valuable function of the tank. It is really the destruction of the sludge. Therefore, this experiment, as I have stated, was made. An exceedingly strong sludge liquor from settling sewage was passed into this tank, the solid matters in the sewage, as it entered, having an average loss upon ignition of 261 parts, while the effluent had only 45 parts loss on ignition, that is, 78 per cent. less. This sewage entering had 4.5 parts free ammonia, while the effluent had 8.7 parts free ammonia. The albuminoid ammonia of this sewage was 3.38

parts and that of the effluent 0.85 of a part; that is to say, the free ammonia nearly doubled while the sewage was passing through the tank, and the effluent contained only 25 per cent. as much albuminoid ammonia as the entering sewage. At the end of 1 year of the operation of this tank the sludge within it amounted to 50 per cent. of its capacity, filled 1 compartment and practically prevented the operation of the tank. At this time the tank contained about 20 per cent. of the organic matter of the entering sewage, and this compared with the organic matter in the effluent showed that 58 per cent. of this matter had been liquefied, given off as gas or otherwise changed by tank action.

The effluent of this tank was very hard to purify upon either intermittent or contact filters without good preliminary aëration. This was due not only to the strength of the effluent, but also to the toxins in the sewage and to the quick exhaustion of oxygen within the filters; that is, an oxidation of organic matter occurred without the formation of nitrates. A septic tank operated during the past year, which is divided into 5 compartments and in which practically all the sludge is retained in the first 2, has not affected the sewage in this way—that is, it is easily purified; but when the sewage remained a number of days mixed with, or above, the putrefying sludge in Septic Tank B previously described, it became of such a quality that it could not be easily purified. The sewage used at Lawrence in these experiments is different from that reaching some areas in the State—although similar to that reaching others—and probably more easily acted upon by the bacteria. When one sees the nature of the sludge retained in some of the larger settling tanks, or upon the surface of some areas, it looks as if it would be a more difficult proposition for the bacteria to work upon than the Lawrence sludge.

BY PROF. LEONARD P. KINNICUTT, WORCESTER POLYTECHNIC INSTITUTE.

I thank you, Mr. Chairman, for calling attention to the work done by the Worcester Polytechnic Institute in attempting to solve some of the problems connected with the so-called septic tank treatment of sewage. This work, however, has been fully reported in print, and I think is known to most of the gentlemen present, and I will only say that the results of the experiments, which were carried on for over 2 years by Mr. Eddy, Superintendent of the Worcester Sewer Department, and myself, with Worcester sewage, and in a closed septic tank holding 1500 gallons, showed that, with an acid iron sewage containing about 74 parts of total solids, of which

15 parts were ferrous sulphate—an amount of organic matter represented by about 0.6 parts albuminoid ammonia, and an acidity equal to 10 parts of sulphuric acid in 100,000 parts—about ¼ of the total solids, 26 per cent. of the organic matter as shown by the albuminoid ammonia, were removed from the sewage, and that the amount of sludge, changed into soluble or gaseous substances, in other words liquefied, was about 25 per cent. of the total solid matter taken from the sewage by the action of the tank.

As to the action of the septic tank on sewage it is what is chemically known as hydrolysis, *i. e.*, the breaking down of complex organic compounds by the absorption or addition of water, which, in the case of the septic tank, is brought about by the action of bacteria or their products the enzymes. The organic substances contained in domestic sewage can roughly be divided into 3 classes—the albuminoids, the fats and the carbohydrates. The albuminoids are organic nitrogen compounds containing a small amount of sulphur, of very complex composition, which can possibly be expressed by the chemical formula $C_{72}H_{112}S.N_{18}O_{22}$. These compounds by hydrolysis are resolved first into peptones, which are soluble in water, and then further broken down, giving organic acids containing nitrogen and organic compounds free from nitrogen. In this process of breaking down of the albuminoids, gaseous products, carbon dioxide, marsh gas, hydrogen, ammonia, nitrogen and probably more or less sulphide of hydrogen are evolved. The fats by the same process of hydrolysis are resolved into organic acids and glycerine, while the carbohydrates yield fermentable sugar, which breaks up into alcohol and carbon dioxide. By this process of hydrolysis, then, the complex organic compounds are broken down into simpler compounds, with the results that a certain amount of the insoluble organic matter in the sewage is rendered soluble, a certain amount of organic matter is removed from the sewage, and the organic matter which remains is more easily acted upon by what are called the nitrifying bacteria. This process of hydrolysis is, as we all believe, brought about by a certain class of bacteria, and the primary object of the septic tank is to cultivate the bacteria capable of producing hydrolysis of these organic substances.

Bacteria, which are believed to be essential for this decomposition of organic matter, or at least are capable of doing this work, are intestinal bacteria. Trade waste does not contain these organisms, indeed it very often contains elements that militate against the life of all bacteria; thus Professor Houston estimates that the sewage of London contains 6,000,000 bacteria to the cubic centimeter, while, according to Dr. Leith, the sewage of the large manufacturing city

of Birmingham contains only 400,000 to the cubic centimeter. Is it not very possible that the reported failure of the septic tank process in certain cases may be due to deficiency in bacterial life, and especially to the class of bacteria especially essential to bring about these first putrefactive changes? It seems to me greater attention should be paid, than is often the case, to the bacterial content of the sewage that enters the septic tank, and further study should be made as to the best method of inoculating a sewage and of cultivating the growth of special forms of bacteria.

I do not for a moment wish it to be thought that the reactions I have outlined give, by any means, a complete explanation of what takes place in a septic tank. Our knowledge is far too limited at the present time to give a complete or even clear explanation of what goes on in the septic tank. It is merely an outline from a chemical point of view how a mixture of complex compounds are transformed into a mixture of much simpler substances. In the process of transformation that takes place in the tank, two things are especially noticeable to the eye—the evolution of gas and the formation of scum over the surface of the liquid. The gas is chiefly a mixture of carbon dioxide and marsh gas, containing at times more or less hydrogen, and the amount, when a tank is in best working condition, will average about 1 cubic foot per 100 gallons of sewage. I also believe, though I am not at the present moment willing to state it as a fact, that much can be told as to whether or not the best results are being obtained in the septic tank process by determining the amount of marsh gas contained in the mixture of gases evolved from the tank, and that failure to obtain about 1 cubic foot of gas for every 100 gallons of sewage, or of a gas containing less than 70 per cent. of marsh gas, is a sign that the best results are not being obtained.

The formation of scum has caused possibly as much discussion as any other factor in connection with the septic tank. As the gases rise to the surface of the liquid they bring with them matters in suspension which tend to form a tough gelatinous scum over the surface of the tank. The scum seems to be more readily formed in a covered tank, where the temperature is more equal and invariably higher than in an open tank. In a tank where sedimentation is fairly complete the scum is often very thin. If a sewage contains very little heavy material and a large amount of light material, especially paper, fibrous and woolly matter, the scum may become so thick that it is very difficult to remove. The formation of the scum depends a great deal on the character of the sewage. There will, as a rule, be less formed with a sewage containing street wash-

ings than in the sewage from the separate system; less from a sewage containing mineral organic waste, as iron salts, cement trade waste, etc., than from one containing the refuse from cotton and woolen mills. This question of the formation of scum has not been as carefully studied as it deserves, though even at the present time we can, knowing the character of the sewage, predict to a certain extent the character of the scum that will be formed, and prevent by a suitable subdivision of the tank the formation of a too troublesome sludge over at least a portion of the tank.

That the septic tank or, as I prefer to call it, the hydrolytic tank has its place in the treatment of sewage, I think few outside of Massachusetts will question. I believe it is not only an essential feature in contact bed and percolating filter systems, but also has its place where irrigation and intermittent sand filtration methods are employed. In this connection I should like to refer to some statements made by Dr. John Duncan Watson, engineer in charge of the Birmingham Sewage Disposal Works, in a recent lecture on "Purification of Sewage, with Special Reference to Sewage Disposal at Birmingham," which lecture, I would say in passing, is one of the best expositions on the subject I have ever read. At Birmingham, as you all know, the method of final purification is irrigation. Formerly the suspended matter was removed by the addition of lime, the sewage containing a large amount of iron salts. Now the suspended matter is removed by sedimentation and septic tanks.

As regards septic tanks, Dr. Watson says: "Difference of opinion has arisen as to the relative merits of anaërobic and aërobic organisms in promoting liquefaction, but it is now almost universally admitted that the cultivation of the anaërobe is an object of the first importance in the first stage of sewage purification. It stands to reason that to attempt to work organisms so evidently dissimilar simultaneously in the same tank will lead to unsatisfactory results. An additional reason for the cultivation of the anaërobe at this stage of the purification process is that the breaking down of fatty matter and cellulose, which embraces substances like paper, straw, fiber, etc., is entirely due to the action of the liquefying anaërobes.

"The Manchester experiments demonstrated that an open tank was quite as efficient in obtaining liquefaction as a closed one; and as the cost of the latter is so much greater, it is not likely to become popular, and probably will not be adopted in future unless for special local reasons. The results which were obtained at Manchester are in accord with the experience which we have had at Saltley; and I am glad to say that notwithstanding the fact that our septic tanks

there, forming, perhaps, the largest collection of such tanks in the world, have, during the past two and one-half years, been entirely free from nuisance.

"It is impossible to give an accurate figure which would represent the amount of sludge the septic tank is capable of liquefying, so much depends on the nature of sewage treated, the length of time it is confined in the septic tank and the amount of suspended matter removed by screening and straining before it reaches the septic tank. The following statement of the result obtained at Saltley, where 20 large tanks, subject to fluctuations, are in daily use, will afford some evidence of the liquefaction obtained under adverse conditions. Crude sewage, as it enters the sedimentation tanks, contains 39.45 grains per U. S. gallon of suspended matter. This is disposed of as follows: 20 grains per gallon, or about one-half of the whole, is ejected down the sludge main and disposed of on land; 14.26 leaves the septic tanks in the form of humus; 5.17 is liquefied and given off in gas."

As showing the amount of purification that takes place in the sedimentation and septic tanks at Birmingham, the following data, taken from a table given by Dr. Watson, are interesting and valuable:

PARTS PER 1,000,000.

Nature of Sample.	Nitrates, etc., as Nitrogen.	Dissolved Solids.	Suspended Solids.	Free Ammonia.	Albuminoid Ammonia.
Computed Average Sewage	0.70	127.6	68.6	4.77	1.73
Sedimentation Tank . . .	0.73	131.8	34.6	4.58	1.32
Septic Tank	0.31	117.9	27.4	5.84	1.01

Nature of Sample.	Chlorine.	Oxygen absorbed in 4 hours.		Alkalinity.	Percentage of Purification.	
		Filtered.	Unfiltered.		Albuminoid Ammonia.	Oxygen Absorption.
Computed Average Sewage	21.8	18.22	0.63	22.2		
Sedimentation Tank . . .	20.6	14.93	9.25	18.2	23.7	18.1
Septic Tank	21.3	12.00	7.18	26.0	41.6	33.0

And in closing, I should like to quote from a personal letter received from Dr. Watson last month, in which he says: "It may interest you to know that we have just cleaned out a septic tank

which has been in use continuously for four years and two months. The amount of irreducible residue occupying the bottom of the tank was equal to nearly one-third of the tank capacity, and I send herewith a copy of the analyses which our chemist has made of that residuum:

ANALYSES.

Total organic matter in dry sludge	44.67	per cent.
" nitrogen in dry sludge	2.47	"
" inorganic matter in dry sludge	55.33	"

The inorganic matter contains:

Siliceous matter (sand, etc.)	20.00	per cent.
Oxide of copper	1.71	"
Oxides of iron and aluminum	20.00	"
" " Zinc, Manganese and Nickel, about	5.00	"
Lime and Magnesia, about	7.00	"
Oxides of Phosphorus and Alkalies, about	2.00	"

BY MR. C.-E. A. WINSLOW, BIOLOGIST, IN CHARGE OF THE SEWAGE EXPERIMENT STATION OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

It is said that young men talk about what they are doing, old men about what they have done and fools about what they are going to do. I am afraid that by calling upon me to-night you force me to place myself in the latter class.

The newest of our septic tanks has been in operation about 2 days, and the oldest of them only 6 months, so that we feel we are just beginning to get a glimmering of light as to the nature of the problem before us. As Mr. Barbour has said, the septic tank is a "live issue," a sort of balanced aquarium, in which certain organisms are carrying out the processes of fermentation; and these bacteria are susceptible to the slightest changes in their environment,—the chemical composition of the sewage, the temperature, and particularly the time during which the process is prolonged, being the main variable factors. Of these, the time element is perhaps the most easily controlled, and we have begun our investigations with this, studying at first very long periods, longer than would be used in practice, since such extreme cases give the best clues to the theoretical principles involved.

The action of the septic tank is apparently two-fold. In the first place we desire to get the solid matter liquefied. In the second place we desire to get the organic matter, in solution, into such a condition that it will be readily acted upon in the subsequent processes. We have found in the former respect that a too prolonged period of

action has an unfavorable effect on the liquefying action, 2 septic tanks run at such a rate that their contents were changed once in 48 hours showing on the average more suspended matter in the effluent than did 2 tanks run at twice this rate.

Furthermore, we have already a little evidence as to the injurious effects of excessive septic action upon subsequent processes of purification. We have 2 systems of double contact beds, 1 pair taking raw sewage and the other sewage septicized for 30 hours. Now, while the septic sewage is more readily acted upon in its passage through the first contact bed, showing a removal of 52 per cent. total and 75 per cent. suspended albuminoid ammonia against 27 per cent. and 62 per cent. for the raw sewage, the effluent appears to be of such a nature that the process in the second contact bed is seriously hampered. The final effluent from the system taking septic sewage shows 60 per cent. removal of total albuminoid ammonia and 79 per cent. removal of suspended albuminoid ammonia against 69 per cent. and 90 per cent. in the case of the raw sewage.

We are planning at present to extend this study by comparing the results of shorter periods of septic action, but evidently it is easily possible to carry the septic process too far.

I am glad of this opportunity to say a word about our station and its purpose. Some of you may know that the Sewage Experiment Station of the Massachusetts Institute of Technology was established last June as the result of a gift by a private individual, whose name is not made public. We have now installed 4 intermittent filters, 6 septic tanks, 9 contact filters and 3 continuous or trickling filters, the capacity of the tanks varying from 64 to 96 cubic feet. Our aims are first educational, since the station affords an unrivaled opportunity for the students at the Institute to study sewage purification; but we also hope that we may in some small way be able to supplement with original investigations the splendid work that is being carried on by the State Board of Health. There is still much to be done on this problem, as you will realize when you consider that we know practically nothing about the nature of the specific organisms which are the active agents involved.

In our work we are very anxious to get the assistance of all those who are interested in the sewage problem. We should like to have all the members of this Section visit our plant, located at 786 Albany Street, at the corner of Massachusetts Avenue, on the line of the largest Boston sewer. We should like to have your advice as to the work we are now carrying on and your suggestions as to researches in the future.

I suppose that one of the aims of this Sanitary Section is to

bring together those occupied with theoretical experimentation and those engaged in the operation of plants on a large scale. I do not know how much in the future the theoretical man may contribute to the practical man, but I know from the theoretical standpoint that only so far as we keep in touch with the actual problems of the day do we feel that we are performing our function to the Institute. I therefore want to express my thanks to the members of the Society who have organized this Section for permitting those of us who are not members of the Boston Society of Civil Engineers to come here and to listen to the interesting papers which have been read to-night, and for the promise of many more such stimulating meetings in the future.

BY MR. F. HERBERT SNOW, CIVIL ENGINEER, BOSTON.

The speaker came here to-night with the avowed purpose of remaining silent, for the reason that he is actively engaged in defending several of the suits in litigation, to which reference has been made; but as this seems to be a kind of experience meeting, the "power" has been coming on as the moments went by and other speakers have left untouched one important phase of the subject, so that now, at the close of the evening, he is really glad and anxious to offer a few remarks, and should anything he may say prove of advantage to the attorneys for the claimants in the said cases, they are welcome to it.

In passing, as one of the members of the Boston Society of Civil Engineers, interested in the formation and success of this Sanitary Section, the speaker wishes to say, that the members of the Sanitary Section have occasion to congratulate themselves on this auspicious beginning of its career: First, because of the gathering of so distinguished a body of original investigators of the septic treatment of sewage as we see about this board; and, second, because at the outset the discussion has taken the form of such broad and free expression of opinion as to demonstrate the fact that the Association is to be more than an "Amen" corner of the Boston Society of Civil Engineers.

While much is known about the putrefying process of sewage disposal, as appears from this evening's consideration of the subject, the speaker has been notably impressed by the knowledge which is lacking, or, in other words, by his desire for certain information, which information, he infers, no one is able to supply, and the natural conclusion, to which it would seem all present must hold, is that the art is very much in its infancy.

The discussion, simmered down, results in this—if the speaker

may be pardoned the conceit—that opinions, rather than practically demonstrated conclusions, must obtain at this stage of the development; but it is only fair to add that those expressed here to-night, while at wide variance in some respects of importance, are based upon personal researches, experiment and experience, and therefore must carry with them great weight.

The investigator who claims not to be an advocate deceives himself. He is such to the extent his mind is enlightened upon the particular subject he is following, and he may be so engrossed in this one line of thought and its collateral work as to lose sight of the real significance of other observed facts. Such has been the case with respect to the attitude of investigators and engineers during the greater part of the last 20 years toward the putrefying process in sewage disposal as disinct from the oxidizing process.

From the earliest times putrefaction has caused trouble and incidentally death, and efforts have been continually made to prevent it. Fifty years ago neighborhood sewage settling tanks were somewhat generally abandoned in England on account of the inevitable nuisance they created, and facilities for handling and treating sewage in as fresh a state as possible were promoted and continued all along the years. About 1878 an innovation was established by one Dr. Mueller, of Berlin, who, in describing his invention, said, as nearly as can be recalled at this moment, that while on one hand the adoption of flush sewers was becoming quite general, so was also, on the other hand, the demand for the use of the water necessarily wasted in operating the sewers, and that this reuse of the water required that it be purified, but that the difficulty in accomplishing this lay in the contained organic matter and the putrefaction it involved; and, further, that while the attempt to remove this nuisance or putrefaction by dilution on a large scale, or by antiseptics or chemicals, or by oxidation in filters or irrigation on land had all proved futile, and investigators had concluded that on purely chemical or mechanical lines the object aimed at, that is, the purification of the organic matter by methods which obviate as far as practicable any putrefaction, was not attainable, his process aimed at purification by promoting the agencies of putrefaction by the methodical cultivation of those small "leaven-like" organisms, to which science was then ascribing the phenomena of fermentation, acidification and putrefaction.

In his tank or apparatus he brought into requisition these organisms, and effected thereby the complete mineralization or "reduction to simple inorganic compounds of the organic matters in the liquid."

So here we see was a recognition of the so-called modern septic process. Four years later, in 1882, one Louis Mouras, of France, patented a sewage-liquefying apparatus, which had for its object the retention and destruction of the solids in sewage in the tank, and the discharge therefrom of liquid only, the intention being to obviate deposits in sewers and thereby reduce the flow in the sewers required for scouring them and carrying away the heavier matters.

This invention was very extensively utilized in Paris and is still in use in some parts of France.

The American right to this apparatus was granted in 1882, and was very fully described with cuts in the *Engineering News* of that year. This article gave an account of the experiment conducted with the apparatus, and showed how solid matters were effectually liquefied in the tank.

Anyone conversant with the art of sewage disposal at that time and with American literature on the subject must have known about this article and the intentional use of the putrefaction process in sewage disposal.

In proof of this we find that Mr. Edward S. Philbrick, whom some of you may have known, and who was a recognized authority on sanitary matters, in a series of articles published the very next year, 1883, described an apparatus of his own, perfected after several years' experiment, which provided for the use of the putrefactive action, and which as perfected he gave to the public for what it was worth, with the comment that the method had been so long in use that claims to proprietorship were not considered valid in his estimation.

His apparatus comprised, among other features, a compartment in which solids were to be separated from the liquid sewage, and retained and become macerated and finely divided by fermentation. So here was an acknowledged American authority, in 1883, recognizing and intentionally using the putrefaction process as described by Mouras and Mueller. But he cautioned its use, and recommended strict attention to proper ventilation of the odors accompanying putrefaction.

And we find no less an apostle of oxidation than the late Geo. E. Waring, stating in his last book published in 1895, in referring to his system of disposal of wastes of isolated houses, as near as can be recalled at this moment,—that in the first of the 2 tanks all of the characteristics of the old-time cesspool may be found, where the sediment and the scum are in a seething mass of putrefaction, emitting foul odors which are objectionable, but he adds, "No way

has yet been discovered in which the foul deposit chamber can be dispensed with."

So we see that the question of a nuisance was a drawback to the putrefaction process, and it was this bugaboo of a nuisance which has agitated the minds of the citizens of every municipality in Massachusetts when a sewage disposal plant has been constructed. It was notably so at Medfield, in 1886, when Elliot Clarke recommended intermittent filtration, and notably so at all the earlier places of installation in the State.

It appears, and is the fact, that while the liquefying putrefying process was known, the sanitary aspect of the disposal problem was considered paramount, and therefore the whole trend of thought and practical endeavor was, during all these years, toward the oxidizing non-offensive process and away from the putrefactive offensive one.

This accounts for the fact that up to 1897 investigators lost sight of the possible advantages which lay in promoting putrefaction to a stage beyond which it had been previously used. But when Cameron, in 1897, exploited his septic tank, an impetus was at once given to research along similar lines.

But even now, after several years of special study, the knowledge of how best to promote liquefaction to a desirable degree, and what constitutes this desirable degree, is a minus quantity, and the observed facts are most contradictory.

Even on the question of practicability and utility of this process we have at loggerheads, here to-night, the leading exponents of the art in America.

The speaker wishes to record his testimony at this time as against the policy of the general adoption of the modern septic tank. The tank of the day is more than likely to cause a serious nuisance in the neighborhood of the installation, unless extreme precautions are adopted. The disposal of the insoluble mineral sludge, together with more or less organic matter, is a most difficult problem, and in every case the speaker knows about is accompanied by offensive odors.

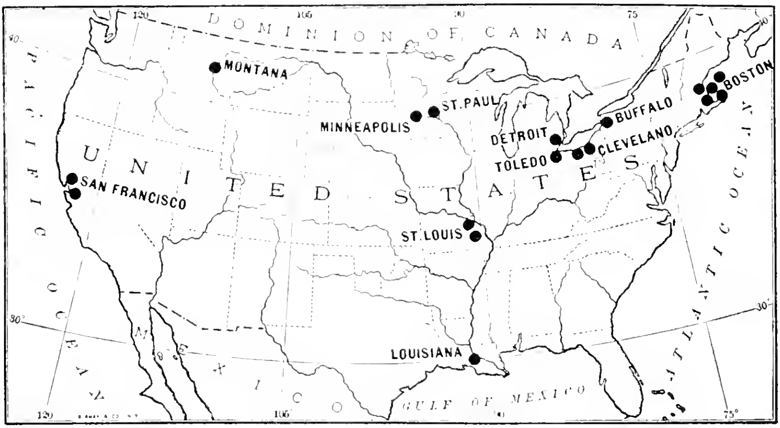
Whether these difficulties are inherent in the process, or may be eliminated by attention to details of design and operation, remains yet to be demonstrated.

The expense of doing this, if it can be done, is a factor for consideration, and also the important fact that the process is on the wrong side of the sanitary fence anyway.

Still further, if the chemical changes in the liquid of any par-

ticular case is likely to render the sewage more difficult to purify, there is an added doubt as to the advisability of the adoption of the process.

So far as the speaker is able to judge at the present time, from his lifetime experience and observation, the staling of sewage in settling tank, disposal of solids while in a comparatively fresh state, and in small quantities, and the oxidation of the supernatant liquid by one of several approved methods, is the safest and very best system for general adoption.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

ASSOCIATION
OF
ENGINEERING SOCIETIES.

Organized 1881.

VOL. XXXII. JUNE, 1904. No. 6.

THE DESIGN OF THE STEEL-CONCRETE WORK OF

ERRATA.

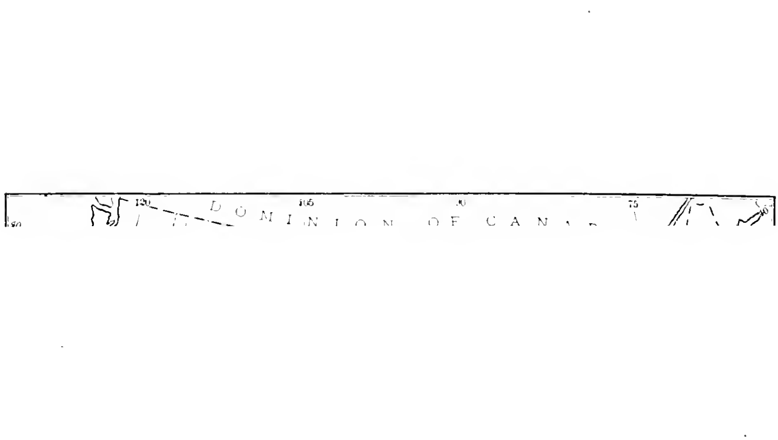
Paper on Steel-Concrete Work of the Harvard Stadium. By LEWIS J. JOHNSON.

Plates II, III, IV, Scale, 1 inch = 6 feet.

winter. The object in the foreground of Fig. 2 is an aisle slab (described below) in an inverted position.

The structure consists essentially of five parallel rows of steel-concrete girders, columns and piers, extending around the U from tip to tip, and supporting a system of steel beams and trusses crossing them transversely (Fig. 3 and Pl. I). This transverse steel work in turn supports lines of steel-concrete slabs running around the U and forming the seating surface. The rows of steel-concrete work are designated by the letters A, B, C, D and E, counting from the interior outward. Fig. 4 shows the four inside rows on the curve, rows A and D not yet stripped. Row A, besides supporting ends of steel beams, includes the front parapet, a wall about nine feet

* Manuscript received January 11, 1904.—Secretary, Ass'n of Eng. Socs.



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VOL. XXXII. JUNE, 1904. No. 6.

THE DESIGN OF THE STEEL-CONCRETE WORK OF THE HARVARD STADIUM.

BY LEWIS J. JOHNSON, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, December 8, 1903.*]

ALTHOUGH the Harvard Stadium is well known in its general character to many members of this Society, it may be well at the outset to recall briefly some of its main features.

The Stadium is a steel-concrete and steel grand-stand, U-shaped in plan, to accommodate some 23,000 spectators at football and other games on Soldier's Field, in the Brighton District of Boston. It is intended to furnish a permanent, fireproof and architecturally pleasing structure in place of the short-lived and unsightly wooden grand-stands hitherto in use. Figs. 1 and 2 show the general appearance of the structure when work was discontinued for the winter. The object in the foreground of Fig. 2 is an aisle slab (described below) in an inverted position.

The structure consists essentially of five parallel rows of steel-concrete girders, columns and piers, extending around the U from tip to tip, and supporting a system of steel beams and trusses crossing them transversely (Fig. 3 and Pl. I). This transverse steel work in turn supports lines of steel-concrete slabs running around the U and forming the seating surface. The rows of steel-concrete work are designated by the letters A, B, C, D and E, counting from the interior outward. Fig. 4 shows the four inside rows on the curve, rows A and D not yet stripped. Row A, besides supporting ends of steel beams, includes the front parapet, a wall about nine feet

* Manuscript received January 11, 1904.—Secretary, Ass'n of Eng. Socs.

in height and continuous around the U. Rows B and C support only steel work; row D supports the outer ends of the steel work and shares with row E the support of two steel-concrete promenades or galleries about twenty feet in width at levels of about 25 and 50 feet above the ground and running from tip to tip of the Stadium. Row E is a line of hollow piers separated by two stories of arched openings, and ultimately to carry a wall at the third story which, with the aid of a colonnade surmounting row D, will support the roof of the upper promenade. The openings of the lower of the two arcades of row E afford access to the stairways to the seating surface, and the openings of the upper afford outlooks from the promenade behind them.

The steel-concrete work includes, besides all the columns, piers, main girders, floors and the seating surface above mentioned, the outside and end walls, the staircases and all parapets and railings. The foundations are all of concrete, some reinforced, some plain. All parts exposed directly to the weather are of steel-concrete.

The developed length of the U at the outside row is 1390 feet, and the uniform width across from front to back of the wings of the U is 98 feet. The area actually under cover is some 120,000 square feet, about 40 per cent. of which is devoted to the semicircular end, and the rest to the two straight wings. The lowest seat is about 8 feet and the highest about 48 feet above finished grade. The number of rows of seats is 31.

The over-all length of the Stadium is 575 feet, and the width is 420 feet, both exclusive of some small towers to occur at each tip of the U and a flight of two or three steps to extend the whole length of the outside. The highest part of the structure now finished is about 53 feet above the ground, but the addition of the covering for the upper promenade will make the final height 71 feet.

Durability, adaptability to rapid construction, coupled with its æsthetic possibilities and moderate cost, are the qualities which led to the use of steel-concrete to the extent above described. The steel work used to supplement it is under cover, accessible for painting, and will be kept isolated from combustibles, and is hence deemed acceptable from the point of view of permanence. It was fabricated while the concrete to support it was being placed, and much time was thus saved, and, under the circumstances, probably some money.

Most of the concrete work was cast in place in wooden forms in the ordinary way, but the slabs of which the seating surface is composed were of a special mixture and were cast in sand molds

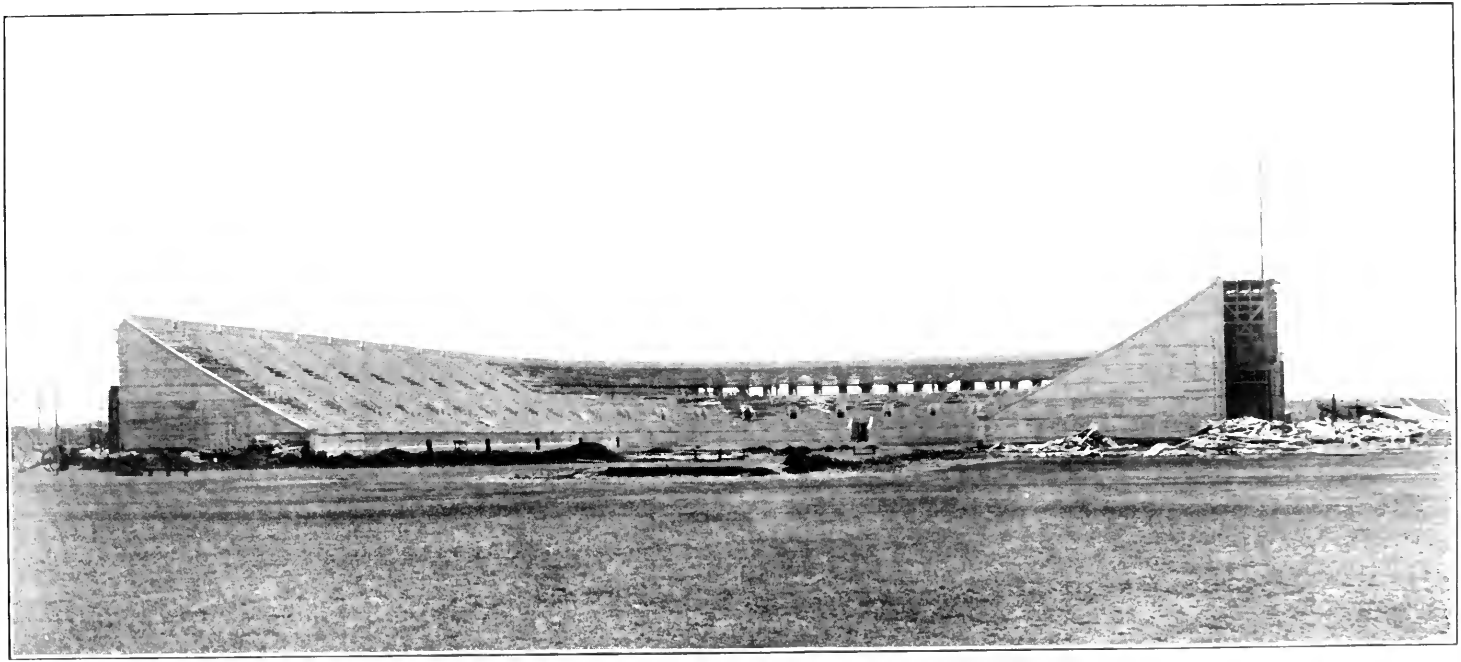

FIG. 1. THE HARVARD STADIUM IN APRIL, 1904, WITH SOME OF THE TEMPORARY WOODEN SEATS IN THE REAR REMOVED TO MAKE WAY FOR THE PERMANENT CONCRETE SEATS.

Fig. 2. Western Façade of the Stadium in April, 1904.

upon the ground in units weighing about 1200 pounds each, and after hardening were hoisted into place and set upon the supports which were meanwhile being prepared for them. The concrete cast in the wooden forms is to be picked so as to remove the board marks, while the seat slabs have a satisfactory surface given by the sand mold. The steel reinforcement in all the concrete consisted of Ransome cold-twisted square steel bars (ranging in size from quarter-inch to inch), supplemented in the seat slabs with a special wire netting with rectangular meshes, electrically welded at the joints.

The concrete was mixed by machinery, two Smith mixers operated by gasoline engines constituting the plant for the purpose.

Constants for use in the concrete design were taken at figures to be regarded as suitable for ordinary Portland cement concrete of 1 : 3 : 6 mixture, though the concrete used was of varying mixtures, always considerably richer than 1 : 3 : 6. An attempt was made to use concrete of special mixtures for special places in the work, but this was found to be impracticable under the conditions—except, as above stated, in the case of the seat slabs.

Three grand divisions of the work went on simultaneously—the casting of the standing concrete (work going on on both wings at once), the manufacture of the structural steel work and of the concrete slabs. The results of these three operations were assembled by the setting of the steel work and the slabs.

The Boston Bridge Works had the contract for the manufacture and erection of the structural steel, but the steel-concrete work was done by day labor, the Aberthaw Construction Company being employed as purchasing agents and as field executives to devise, install and operate the steel-concrete construction plant.

The Harvard Athletic Association furnished the general and detailed designs for the entire structure, the architecture being in the hands of Messrs. C. F. McKim and G. B. de Gersdorff, of New York; the engineering design was the work of Mr. J. R. Worcester and the writer, and the whole was under the direction of Professor I. N. Hollis.

The foundations are of the simplest character, as borings showed only hard gravel and clay to a depth of at least 40 feet. They are mere concrete or steel-concrete blocks laid on the natural ground just below frost, so proportioned as to keep the maximum pressure on the ground from exceeding 7000 pounds per square foot.

The methods and principles followed in the design of the re-

mainder of the concrete work may conveniently be taken up under three general heads, viz:

(1) Columns.
(2) Girders (simple and cantilever).
(3) Walls and parapets.

COLUMNS.

All the columns contain twisted rods in the form of verticals at the corners, with or without horizontal hoops at close intervals (Pl. II). This steel was not, however, counted on as furnishing compressive resistance. Its utility was conceived to lie in withstanding any slight flexure that might come upon the columns from lateral forces due to temperature changes or other causes. This reinforcement consisted of three-eighths and half-inch rods, depending on the size of the column, one such rod being placed near each corner of the column. In order to guard against the risk of such slender rods buckling when too near the surface, square hoops of quarter-inch rods encompass them in horizontal planes at intervals, keeping their free or unsupported lengths within reasonable limits.

Besides adding flexural strength, as just described, this steel furnishes some protection against the failure by shearing on planes inclined about 55 degrees to the horizon characteristic of prisms of materials like plain concrete. It was not overlooked that Professor Hatt found* reinforced concrete prisms to stand compression rather less well than plain ones, but it was by no means clear that his conditions were repeated in the Stadium, and the desirability of a slight amount of flexural strength already mentioned, and of the increased protection furnished by the steel against shrinkage or other cracks, made it seem on the whole preferable to use it. The columns proper range in size from 14 x 14 inches to 24 x 33 inches. Besides these, and designed in the same general way, with corner vertical rods and horizontal hoops, except that they are hollow, are the piers showing in the outside wall and already mentioned, which are externally 66 x 36 inches (Pl. Vb), the walls along the 66-inch side being 4 inches thick and the other two 6 to 8 inches thick, the 8 and 6-inch ends being counted on as furnishing the whole compressive strength.

The cross-sections of the columns were determined by applying an allowable compressive stress of 350 to 400 pounds per square inch to the maximum combined live and dead load, increasing the results thus obtained whenever necessary to keep the ratio of the

* *Engineering News*, July 17, 1902, p. 54.

length to least side of column down to about twelve, or to give round numbers for dimensions of the section. The structural steel work and concrete girders and struts were arranged to aid in keeping down the ratio of length to least side.

GIRDERS.

Out of the multitude of methods advanced for the design of steel-concrete girders, one based upon the observations of Prof. W. K. Hatt* was adopted throughout the work. This method seemed at least as rational as any; it gave conservative results, and (thanks to suggestions drawn from Mr. J. W. Schaub's letter in the *Engineering News* of April 30, 1903, p. 392) was very easy to use. This method ignores the tensile strength of the concrete, assumes a parabolic distribution of compressive stress and assigns a position to the neutral axis dependent upon the percentage which the cross-section of the steel tension flange bears to the whole cross-section of the girder. The proper and economical percentage of steel being dependent upon the relative cost of concrete and steel, about seven-tenths of one per cent. was a value commonly used in the Stadium, though it is a question whether a higher one might not have been generally more economical. With the assumed steel percentage, the maximum unit compressive stress in the concrete was determined for the load which would be supported at the appearance of the first crack on the tension side, and a fraction of this load was taken as the allowable load, this fraction being the ratio of the assumed allowable 500 pounds per square inch to that figured out by the parabolic principle as the maximum at the time of the first crack. Thus the maximum working compressive stress on the concrete is believed to be kept from exceeding 500 pounds to the square inch.

The appearance of the first crack was assumed to be accompanied by a tensile unit stress of 36,000 pounds per square inch in the steel. This is considerably below the elastic limit of the steel used, but it implies an elongation of about one-eighth of 1 per cent., which was taken to be as much as even armored concrete should be trusted to stretch without a crack.

To illustrate the meaning of the preceding, let us suppose the load upon a beam of given dimensions with a given percentage of steel located in a given position to be 75,000 pounds when the stress in the steel is at 36,000 pounds per square inch (assumed to accompany first crack), and that at the same time the maximum

* *Engineering News*, February 27, 1902, p. 170, and July 17, 1902, p. 53.

compressive stress on the concrete figures out by the parabolic principle to be 2000 pounds per square inch. The allowable value of the last quantity being assumed to be 500 pounds per square inch, the safe load on the girder would be $\frac{500}{2000}$ of 75,000 or 18,750, thus implying a working unit stress in the steel of only $\frac{500}{2000} \times 36{,}000$ pounds, or 9000 pounds, without counting on any assistance from the tensile strength of the concrete.

If, as would be the case with lower percentages of steel, the compression on the concrete should fall below 1125 at the appearance of the first crack, the steel would be the guiding factor instead of the concrete, and a fraction of the figured load would be chosen so as to keep the stress in the steel down to 16,000, even if the stress in the concrete should then run considerably below the allowable 500. The writer is inclined to avoid such low percentage of steel as generally lacking in economy, but circumstances may arise where thickness of slabs and depths of girders are determined by considerations of rigidity or of provision against abrasion. Here there can be no objection to a low steel percentage if the unit stress in the steel is kept within safe limits. It should be remembered that failure of a girder due to the fracture of the steel would be a sudden failure, far more dangerous to life than failure by cracking or crushing the concrete. Total failure would come about in the latter case gradually if at all, giving warning to the occupants of the structure. The abuse which a concrete girder with a fair proportion of steel will stand, and the warning which it will give before utter collapse and dropping its load, is one of the properties of steel-concrete not always appreciated.

The method above outlined may seem complicated and difficult to use, but with some predetermined constants on file for reference it is, on the contrary, very easy to use in practice, as will be shown later. It is admitted that from the point of view of rationality it has its weak points, as have other methods of steel-concrete computation. It leads to larger sections than some other methods professing to keep the unit-compressive stress in the concrete down to 500 pounds—producing an additional margin of safety not unwelcome in a structure like the Stadium.

The constants mentioned in the preceding paragraph may be worked out as values of K* such that the moment of resistance of a

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*Since this paper was put in type the writer has observed that Professor Hatt has suggested the use of K's of a similar character and has given numerical values for several of them. They will be found at the close of his paper, "Tests of Reinforced Concrete Beams," Proc. Am. Soc. Testing Materials, Vol. II, 1902.

concrete beam with breadth b and depth h may be expressed simply as $M = Kbh^2$, where K is a numerical coefficient depending, for a given u and $\frac{F_s}{E_c}$, simply on the steel percentage and can be taken from a table. A brief table of this sort is given herewith (Table I).

TABLE I.

VALUES OF K FOR VARIOUS PERCENTAGES, p, OF STEEL.

$$u = 0.97;\ \frac{E_s}{E_c} = 7.5;\ f_s = 16{,}000;\ f_c = 500.$$

p	K	p	K	p	K	p	K
.001	15	.006	66	.012	86	.030	116
.002	29	.007	70	.014	91	.040	125
.003	43	.008	74	.016	95	.050	133
.004	56	.009	77	.018	98		
.005	61	.010	80	.020	102		

It was compiled from Professor Hatt's* formulas for the resistance of beams at the first crack, following Mr. J. W. Schaub in using 7.5 for the ratio of E for steel in tension to that of concrete in compression, and modified for the lowest values of p as above explained to prevent the compressive stress in the concrete and the tensile strength of the steel from exceeding 500 and 16,000 pounds per square inch, respectively. The center of gravity of the steel in the section is supposed to be 97 per cent. of the depth of the beam from the top, this percentage being called u. As u frequently differs from 0.97, it should be noted that the h which should be used for determination of strength and steel percentage may be taken, within ordinary limits at least, at a value 97 per cent. of which will be the actual distance from the top of the girder to the center of gravity of the steel.

For example, suppose the maximum flexure in a given beam, including an allowance for its own weight to be 2,000,000 inch pounds and the proportion of steel to be assumed at 0.007, required the size of the beam. Taking 70 from the table as the proper value of K, $bh^2 = \frac{M}{K} = \frac{2{,}000{,}000}{70} = 28{,}570$ in.^{3} The b and h can then be selected, b frequently being determined by a column width, or other such consideration. If b be 16 inches, h follows at $\sqrt{\frac{28{,}570}{16}} = 42.3$.

* *Engineering News*, July 17, 1902, p. 56.

If the center of gravity of the steel must be 2 inches above the lower face, making $u = \frac{42.3-2.0}{42.3} = 0.951$, *i. e.* less than 0.097, the actual gross depth of the beam to be used would be $2 + 0.97 \times 42.3 = 2 + 41.2 = 43.2$, or, for round numbers, say 44.

The weight of the beam being thus determined, the allowance for flexure due to this weight can be checked and the beam re-dimensioned if necessary. The dead weight of such beams being relatively a large item, this point needs attention accordingly. The b and h once selected $0.007 \times 16 \times 42.3$ will determine the total section of steel in the girder which can be made up of rods in various ways to suit conditions. The number of rods may be so large as to require their being put in several rows, and the u, and hence the effective depth of the girder, may thus be reduced so that b and h may have to be determined anew.

An alternative method of computing beam sections is that in which u is taken as unity, and the resulting h is the distance from the top of the beam to the center of gravity of the steel. The actual depth of the beam will be found by adding a suitable thickness of concrete below the steel to embed and protect it properly. Table II gives values of K to be used in this way, figured for the value of 7.5 for $\frac{E_s}{E_c}$ as before, and also for the values 6 and 10 for that ratio. The value 6 seems likely to be the one valid after the concrete is several months old and in actual normal service. It is interesting to see how comparatively slightly K is changed by these variations in $\frac{E_s}{E_c}$. The values of K in Table II, as well as in Table I, are for 500 pounds as the maximum compressive stress on the concrete, and 16,000 as the maximum tension in the steel. For values of p at 0.003 or less (for $\frac{E_s}{E_c} = 10$ this limit is 0.005) the concrete is at less than 500 pounds compression when the steel is at 16,000 pounds tension. Above these limits of p the steel is not worked up to 16,000 when the concrete is at 500 by a margin which increases with p.

The amount of concrete added below the steel should in all cases be kept at a moderate percentage of the depth, for though the concrete is not relied upon in tension, it will, of course, take some tension, and if it should reach much below the steel it would be likely to show a crack prematurely and expose the steel to corrosion. On the other hand this thickness must be sufficient to afford adequate fireproofing for the steel as well as protection against corrosion.

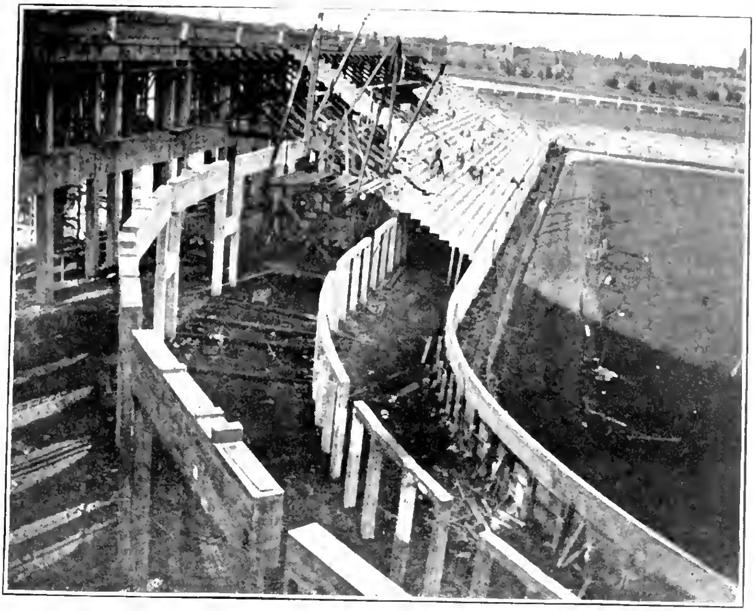

Fig. 3. Part of Curve and West Wing under construction.

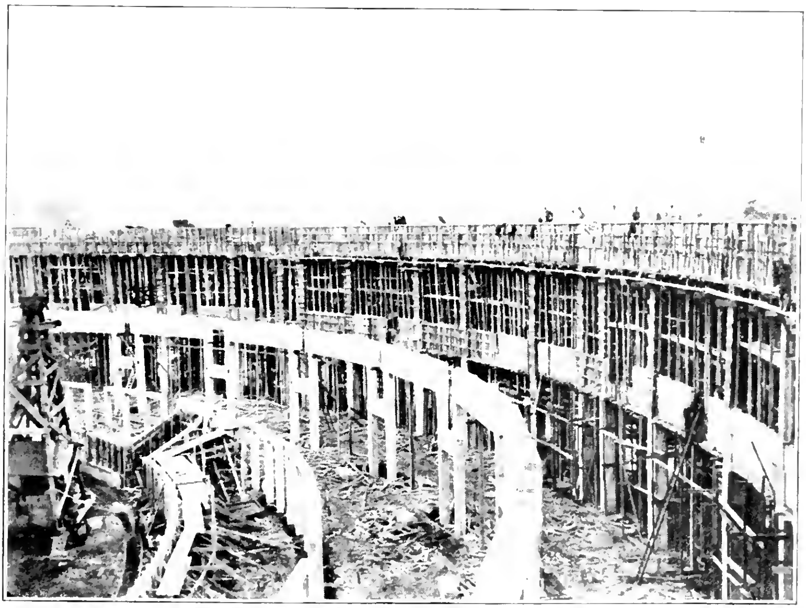

Fig. 4. Central Part of Curve under construction.

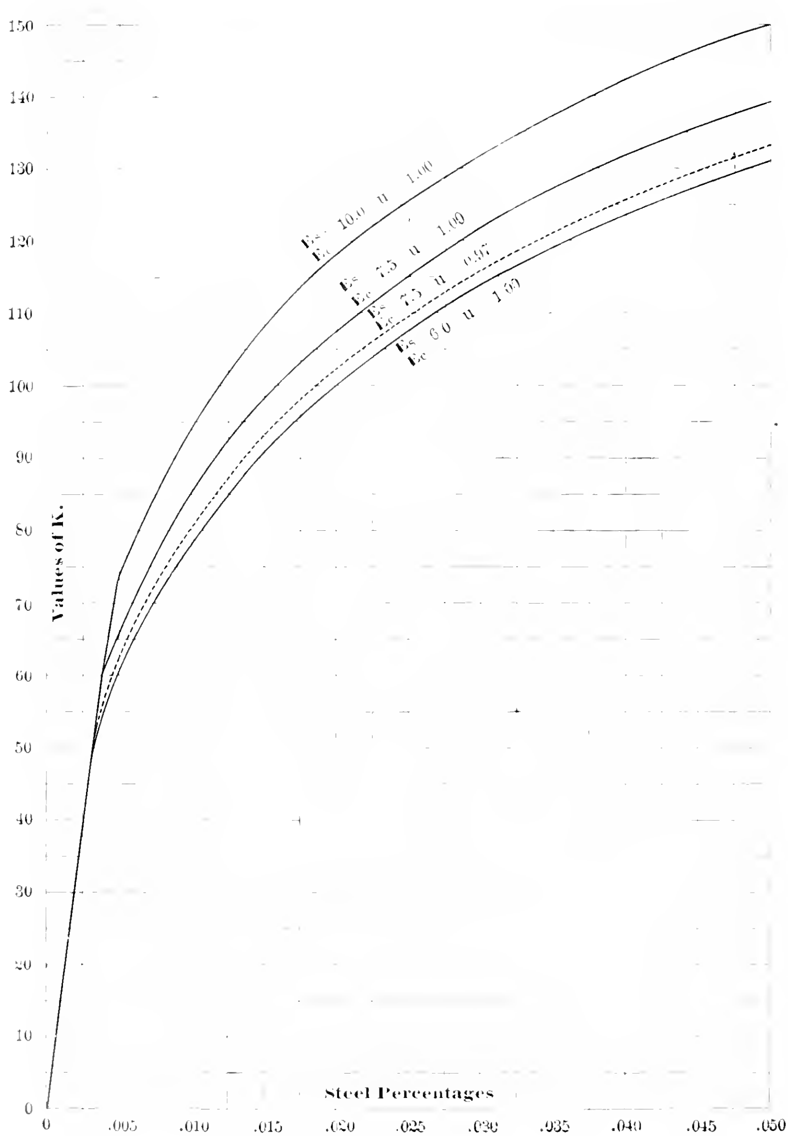

FIG. 5. CURVES SHOWING K'S FOR VARYING $\frac{E_s}{E_c}$ AND u, CONSTITUTING A GRAPHICAL EQUIVALENT OF TABLES I AND II.

To make plain the method of figuring with u = 1.00, the preceding numerical example will be repeated here.

Assuming steel percentage as before at 0.007, and taking K = 74 from Table II, $bh^2 = \frac{M}{K} = \frac{2,000,000}{74} = 27,000$ in.^{3}, and $h = \sqrt{\frac{27,000}{16}}$ = 41.1 inches. Adding 2 inches below the steel, the depth becomes 43.1 inches. The amount of steel becomes 0.007 × 16 × 41.1 = 4.6 square inches—a shade less than before.

Fig. 5 shows the K's of Tables I and II plotted with the values of p and K as abscissas and ordinates respectively. Here can be seen the relative effects of changes in u and $\frac{E_s}{E_c}$. It may be observed that with concrete old enough to give the value 6.0 for $\frac{E_s}{E_c}$ it might be permissible to allow a unit compression on the concrete above 500 pounds and diminish the already inconsiderable difference between the K's for the ratios 6.0 and 7.5. The values of K except for the percentages below 0.003 to 0.005 are directly proportional to the allowable unit compression on concrete. The values in the table being for 500 pounds per square inch, K's for other values can be easily computed accordingly.

The value K may be expressed generally for the values of p above 0.003 to 0.005 as follows:

$$K = \frac{2}{3} f_c x \sqrt{1 - \frac{3}{8} x}$$

where f_c is the allowable compressive stress in pounds per square inch on the concrete, and

$$x = -\frac{3}{4} p \frac{E_s}{E_c} + \sqrt{\frac{3}{2} \frac{E_s}{E_c} p \left(u + \frac{3}{8} \frac{E_s}{E_c} p \right)}$$

For the low values of p not covered by the preceding,

$$K = f_s p \left(1 - \frac{3}{8} x \right)$$

where f_s = allowable tensile stress per square inch on the steel, — other letters as before.

The K's are seen to be quasi allowable fiber stresses. Multiplied by the area and length expressed by bh^2 they give a moment of a couple, the resisting couple in the beam, as they should. The K's multiplied by 6 give quantities comparable with the fiber stresses allowed in rectangular wooden beams. It thus appears that a steel-concrete beam is generally considerably inferior in carrying capacity to even a spruce beam of the same breadth and depth.

Before leaving this part of the subject it may be worth while

to point out that Mr. A. L. Johnson's four formulas* for strength of "average rock concrete" may be condensed, using a factor of safety of 4, into $M = 87.5\ bd^2$ with u at 97 per cent., and give for p almost exactly 0.007. According to this method of figuring, the K given in Table I as 70 would correspond to a factor of safety of 5. It seems likely that other formulas for strength of steel-concrete beams might be put into the form $M = Kbh^2$.

TABLE II.

VALUES OF K, FOR VARIOUS PERCENTAGES, p, OF STEEL.

$u = 1.00$; $f_s = 16{,}000$; $f_c = 500$.

$E_s / E_c = 6.0$		$E_s / E_c = 7.5$		$E_s / E_c = 10.0$	
p	K	p	K	p	K
.001	16	.001	15	.001	15
.002	31	.002	30	.002	30
.003	45	.003	45	.003	44
.004	54	.004	60	.004	59
.005	59	.005	65	.005	73
.006	64	.006	69	.006	78
.007	68	.007	74	.007	82
.008	72	.008	78	.008	86
.009	75	.009	81	.009	90
.010	78	.010	84	.010	94
.012	83	.012	90	.012	100
.014	88	.014	96	.014	105
.016	93	.016	100	.016	110
.018	96	.018	104	.018	114
.020	100	.020	107	.020	118
.030	114	.030	122	.030	132
.040	124	.040	132	.040	142
.050	131	.050	139	.050	150

Furthermore, it may be recorded that alternative somewhat simplified forms of Professor Hatt's expression $M = bh^2 \left(\frac{5}{12} f_c x^2 + p\ f_s (u - x)\right)$ for the moment of resistance of a steel-concrete beam ignoring the tensile strength of the concrete are $M = bh^2 \times p\ f_s\ (u - \frac{3}{8}x)$ and $M = bh^2 \times \frac{2}{3} f_c\ x\ (u - \frac{3}{8}x)$. The coefficients of bh^2 in these three equations are the K of the preceding. The first one containing both f_c and f_s requires the insertion of consistent values for these two terms, and is hence awkward for use. Either of the last two is free from this difficulty,—working values can be sub-

*_Railroad Gazette_, March 13, 1903, p. 183.

stituted at will for f and c. Of course the one giving the smaller value of M is the one to be used in any case. The values of K tabulated above are, as above explained, the values of these coefficients which will give these decisive values of M.

The foregoing is the basis of determination of the cross-section of the girder and of the steel in the tension flange. The vertical reinforcement was given no less consideration. The recommendation of the French authority Christophe* not to permit beams in which the average vertical unit-shear oversteps 14 to 30 pounds per square inch to go without vertical reinforcement of steel, supported as it was by experiments† by the writer, was adopted.

Accordingly, stirrups or frames made of Ransome rods were used in all girders where the shear exceeded about 20 pounds per square inch. These stirrups were made of two and in some cases three U's (Pl. II), bent and wired together to templet. By being accurately made, they aided in the correct distribution of the lower flange rods. The stirrups so made were put in a plane transverse to the girder (Pl. II), usually vertical, and cross-sectioned and spaced so that at intervals along the beam not exceeding the depth of the beam there was a sufficient cross-section of stirrup to take up in tension enough of the vertical shear to leave a balance which, divided by the gross cross-section of the girder, would amount to not exceeding 25 pounds per square inch. In some of the smaller girders and in critical points in the largest ones the stirrups could take up the whole of the shear without overstepping 16,000 pounds per square inch in the steel. Care was taken in all cases to see that the stirrups had sufficient anchorage above and below the middle of the girder to develop their tensile strength without danger of pulling through the concrete. As a further precaution in this line, the rods at the open ends of the stirrups were bent at right angles (Pl. II). These vertical frames or stirrups suggest the verticals of a Howe truss, the intermediate concrete furnishing the diagonal compression members completing the analogy with such a truss. The analogy is with a double or multiple intersection truss if the stirrups appear at intervals of less than the depth of the girder. Another analogy is with the stiffeners of a plate girder, the stirrups of the concrete girder supplementing deficient tensile strength just as the stiffeners supplement deficient compressive strength. As with stiffeners, the most efficient position, other things being equal, would be at an

* Christophe: *Le Béton Armé*, 2d Ed., p. 635.

† See Appendix.

inclination of 45 degrees, and, as with stiffeners, there are objections to their being set otherwise than vertical, especially when independent pieces of metal form the flange tension rods.

The steel-concrete beam work included simple girders, 24 feet 9 inches in span, with sections 16 x 47 inches, 18 x 45 inches, 22 x 60 inches (Pl. II), and 24 x 60 inches, and (Pls. III and IV) two systems of curved (radius 190 feet) cantilever girders in row D with sections 18 x 45 inches and 24 x 60 inches respectively. The cantilever system permitted the retention of the same cross-section throughout the curve in this line of girders as was used on the tangent, and to some extent counterbalanced the rotary effect of the curvature of the girder. The ends of cantilevers and of suspended spans being critical points subject to very severe shear, they were stepped so as to reduce the effective concrete area as little as possible and armored with special care. The stirrups used here were of special construction, placed in an inclined position, and were designed to resist the whole vertical shear.

The cantilever ends tend to act as joints at which the shrinkage stresses are relieved. The first suspended span to be built shortened in hardening and slipped on the treads of one of the stepped ends so as to show a crack throughout the extent of the risers of the joint, and in slipping spalled the corners of the steps slightly. After this, four 1-inch rods were put in at mid-height of the girder and lengthwise with it, crossing the joint and extending into both the cantilever end and suspended span far enough to develop the strength of the rods with a view to prevent this slipping, and, so far as seen, the result has been a success. Shrinkage joints are thus kept about 115 feet apart in this line. At the ends of these intervals are opportunities for shrinkage to take place harmlessly. Besides using the rods, the steps were finished off with a troweled surface truly level, so as to leave things in shape for a harmless slip should the rods prove ineffective. It was at one time planned to use two quarter-inch steel plates lubricated with graphite at each of these treads to facilitate sliding and to prevent spalling, but it did not finally seem necessary to go to such a length.

These lines of cantilever girders were subject to a very complex set of loads and were much cut up by promenade floor beams and passageways for stairs. The girders in row C, on the curve (Fig. 3 and Pl. II), were all straight—a series of chords—but they support the ends of trusses and are hence much larger than the girders of the same row on the tangent, their section being 22 x 60 inches as against 16 x 47 inches.

The promenade floors were made of slabs of inverted trough

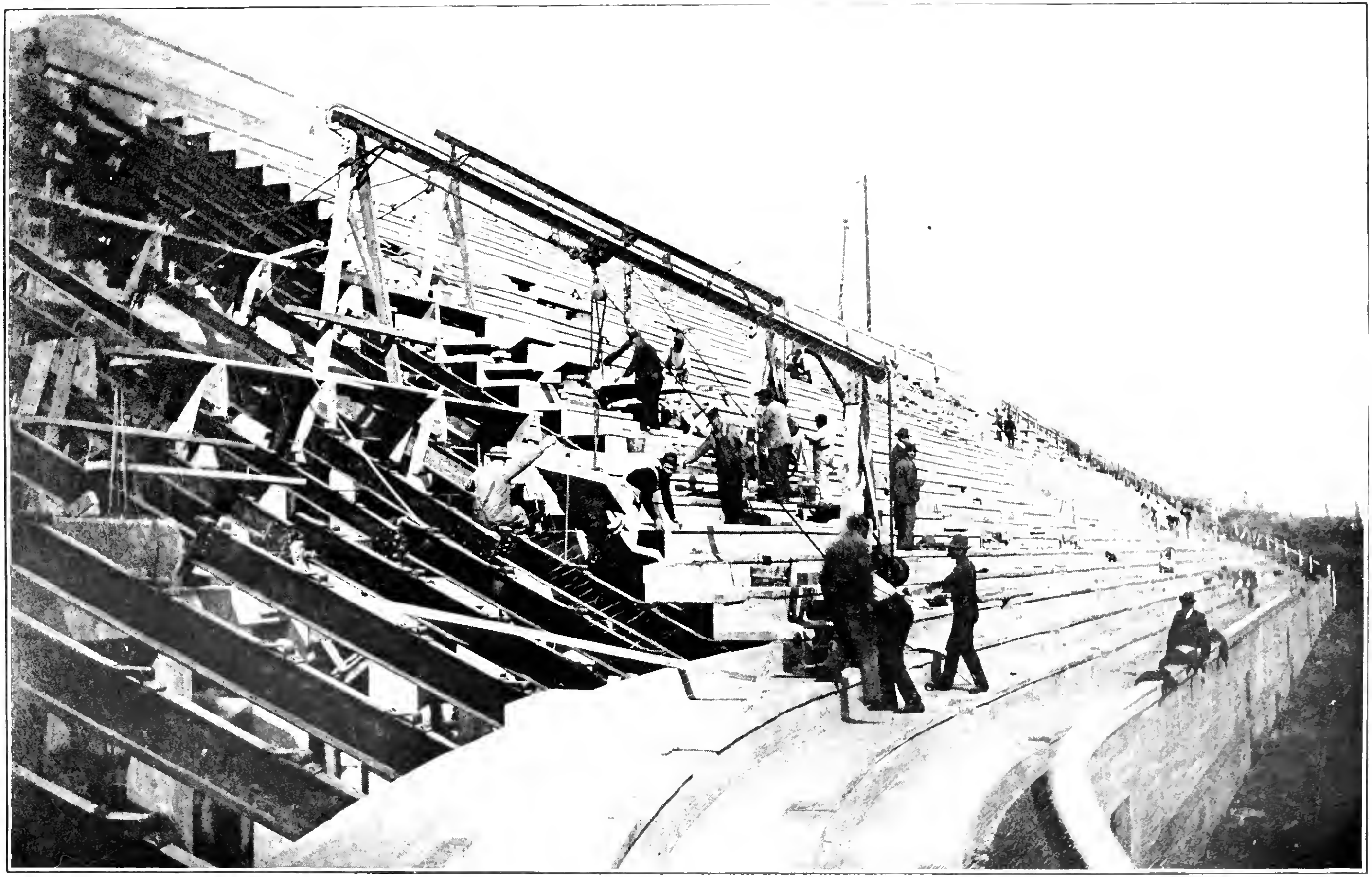

Fig. 6. Setting Seat Slabs on the West Wing.

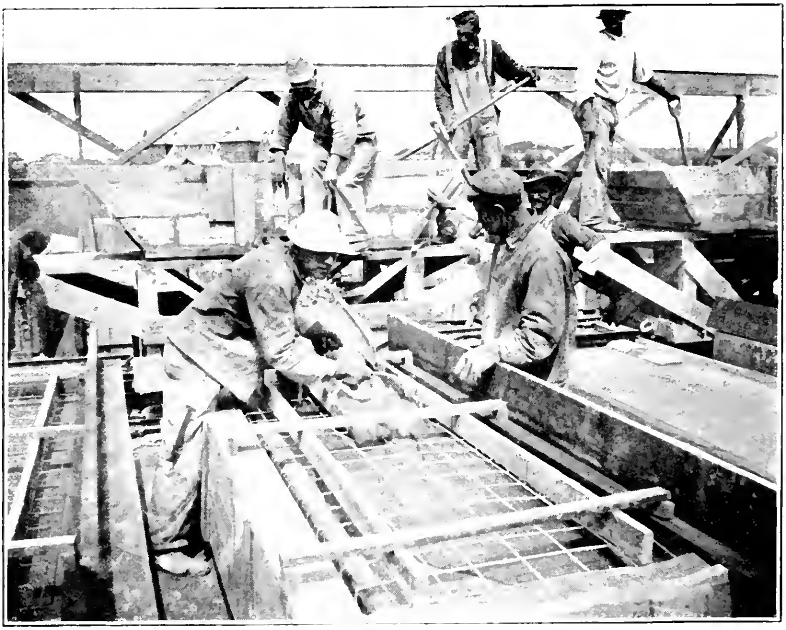

FIG. 7. CASTING A SEAT SLAB.

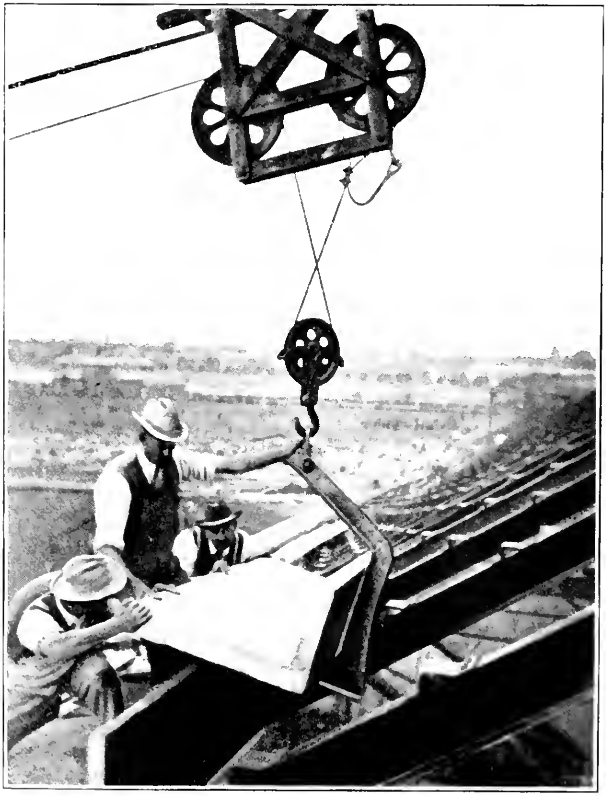

FIG. 8. METHOD OF HANDLING SEAT SLABS IN SETTING.

section (Pls. II, III and IV) about 8 feet 3 inches wide and some 20 feet in span, cast alternately in place, thus providing shrinkage joints at the edge of every slab; the thickness of the body of the slab is $4\frac{1}{2}$ inches, exclusive of the granolithic finish, and the flanges are 6 x 18, making practically a $4\frac{1}{2}$-inch flat floor resting on 12 x 18 joists 8 feet 3 inches on centers and 17 feet in span.

The seat slabs are a series of ⌟s set up so as to form a flight of treads and risers (Fig. 6 and Pl. I). They are of crusher-dust concrete (poured at a consistency of cream) reinforced by a half-inch rod at the base of each riser and electrically welded steel wire netting with rectangular mesh furnishing straight wires 0.162 inches in diameter, 5 inches on centers running across the treads and up the risers. The wires running the other way are somewhat smaller and closer together. In the treads this netting furnishes the ordinary tensile reinforcement for the span from riser to riser, besides hanging one edge of the tread to the base of the riser, and in the risers it furnished vertical reinforcement against shear, for the risers constituted a series of joists running from one steel beam to the next, the span being usually 8 feet 3 inches. Fig. 7 is a view of the sand casting process. In the foreground is seen the method of supporting the reinforcement while the mold is filled. At the right is a similar mold filled with hardening concrete.

These slabs were cast in small units of about eight cubic feet each to facilitate handling and to provide amply against shrinkage cracks. They were some 4800 in number, and, including those on the curves, required ninety-five different patterns, counting rights and lefts as alike, and in many cases counting as alike such patterns as varied only slightly in length. On the semicircle they were made curved, but a constant radius was used for all, regardless of their distance from the center. The true radii would have had thirty-one different values, ranging from 115 to 189 feet, but 166 feet 8 inches was chosen as a convenient mean to use for them all.

The handling which all these slabs underwent in storing and placing formed an automatic system of testing, which was considered a distinct advantage of the method of manufacture. They were cast with one-eighth-inch allowance for end joints, but the sand casting proving to be a less accurate process than was expected, more or less picking and clipping had to be resorted to in setting them. An additional and probably more important cause for such modifications was inaccuracy in the steel-setting. Fig. 8 shows in detail the method used for grappling the slabs for hoisting and setting.

The treads of these slabs are an illustration of concrete reinforced with a small percentage of steel and accordingly rated for strength from the point of view of the steel. This strength is ample almost to excess, even with this small allowance of steel, yet thinner sections of concrete were not seriously considered, three and a quarter inches on the average being adjudged a suitable minimum from the point of view of resistance to abrasion, shocks, etc., and the omission of the steel netting altogether was, of course, not seriously entertained—even though the concrete might, by counting on its tensile strength, be figured out as strong enough.

WALLS AND PARAPETS.

The special problem in the design of the walls and parapets which will be considered here is how best to provide for shrinking so as to minimize the evil of cracking from this cause or from temperature changes. One way is frankly to leave joints at short intervals free to open, using steel reinforcements between these joints to compel all the cracking effect to appear, if at all, at the joints left. These joints are supposed to open in tolerably straight, clean cracks, less unsightly than random cracks would be. They are unsightly enough, however, and it is difficult to make the cracks turn out as straight as expected. There is, therefore, a strong incentive to resort to the other method of treatment and attempt to present all cracks from temperature and shrinkage changes by the aid of proper reinforcement with steel. M. Considère's experiments afford a rational basis for expecting success from such a venture, reinforced concrete having been shown by him to be capable of stretching, without showing cracks, to an extent far greater than that of plain concrete. Mr. A. L. Johnson reports* actual success in building a concrete wall 300 feet long, 8 inches thick and exposed on both sides to the weather, without any joints, and with no cracks appearing in the first year, or up to the time of his report

In the outside wall of row E of the Stadium there was nothing else to do but to depend upon steel reinforcements to prevent shrinkage cracks. It was a place where cracks of any kind would be most objectionable. Expansion joints were left at intervals of 16½ feet, as in the front parapet, but they had to be placed over the center of the piers, in spite of its being realized that the friction from the weight of the superimposed mass would probably prevent all sliding, and thus prevent such joints from being effective. The amount of shrinkage to be expected in setting, or cool-

* *Railroad Gazette*, March 13, 1903, p. 183.

ing to the minimum temperature, was estimated not to exceed about 0.0005 to 0.0006 of the length. Professor Hatt found* that 1:2:4 concrete with 1 per cent. reinforcement would stretch 0.00088 before cracking. Considère and A. L. Johnson lead us to suppose that this stretch may be considerably more. At any rate, the margin seemed sufficient, and as the two faces of the wall in question were only 4 inches thick, 1 per cent. reinforcement was quite feasible—only a half-inch rod every six inches being required—and was adopted (Pl. Vb). Thus far, after several months from the completion of the first of this work, neither crack nor opening of the joints in the whole extent of the two lines of nearly 1400 linear feet each (with one or two insignificant exceptions) has come to the writer's notice. The joints not opening show that the concrete between them must have stretched as expected. The results of the winter's exposure are looked forward to with much interest.

The front parapet was executed upon the principle first mentioned, shrinkage joints being left every 16½ feet, which opened perceptibly immediately upon the hardening of the concrete, and now constitute open joints sometimes a sixteenth of an inch in width, changing as the temperature rises and falls.

The experience with the back wall being reassuring, and the tying together of row D into continuous sections of about 115 feet each causing no harm, it was determined to apply the same principle to the broad expanse of the end walls, which forms the finish at the tips of the U (Figs. 1, 2, and Pl. Va). These walls are some 75 feet long and from 9 to 50 feet high. They are in the main mere curtain walls only 4 inches thick, supported by a series of columns with which they are monolithic. These walls are armored freely with quarter-inch rods—less care being taken to keep the percentage up to 1 per cent. than was observed in the back wall, the smaller area involved being regarded as justification for venturing below the 1 per cent. These walls have now been stripped several weeks, and so far no cracks in them have come to the writer's notice. Fig. 9 shows the centering for one of these end walls, also the mold for one of the row C girders and in the distance many finished seat slabs on the ground ready for hoisting and setting.

It was seen, as the work progressed, that the completion of the Stadium with all the architectural ornaments before the Yale game was out of the question, but work was pushed on the parts essential for carrying the seats, and by the use of temporary wood work instead of concrete slabs on the steel beams of a portion of the

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* *Engineering News*, July 17, 1902, p. 55.

structure, the whole seating surface was ready for use some days before the Yale game, and on the day of that game, five months and two days from the setting of the first batterboards, and less than five months from the turning of the first shovelful of earth, the Stadium was occupied comfortably to its full final capacity.

It is expected that the work will be taken up anew in the spring and pushed rapidly to completion. As will be seen by comparing Figs. 1 and 2 and Pl. I, a prominent part of the work still to be done is the construction of the colonnade along the top of row D, and the roof of the top promenade.

APPENDIX.

Fig. 10 shows beams I (and 2), III, VIII and IX after being broken in a series of tests last spring and referred to in the preceding paper as illustrative of the relative behavior of beams with and without vertical reinforcement. Beam I, with only longitudinal reinforcement, was tested in conjunction with a beam (2) of ⊔ section in a way to make it of interest here as showing the curved break, repeated more perfectly in III and partly approximated in VIII. This curve approximates the curve of maximum internal tension with remarkable closeness—a result due, no doubt, to the high degree of homogeneity attained by the very fine and graded aggregate. This curve shows pretty clearly that failure by shear is closely associated with failure by tension of the concrete.

The methods of loading and supporting the last three beams are shown in the figure.

Beams III and VIII failed in the manner shown, with the end shear at 111 and 100 pounds per square inch, respectively. Beam IX at failure in a totally different manner was resisting a shear of 132 pounds per square inch with no signs of failure by tension above the reinforcing rod or shear. Beams VIII and IX differed in no respect save that the latter had vertical reinforcement and the former had not; and both being cast from a mixture of cream-like consistency, it seemed fair to infer from this pair of beams that a shear of 50 to 80 pounds per square inch sometimes spoken of as allowable without reinforcement, in ordinary concrete was higher than it was safe to permit in this structure. It should be noted, moreover, that the first crack in the vertically reinforced beam did not appear till the load was 2540, while in VIII it appeared at 1500. Undoubtedly more experiments should be made along this line, but in lack of such these two beams were taken to indicate the desirability of the reinforcement. The concrete was rich (one part cement to two

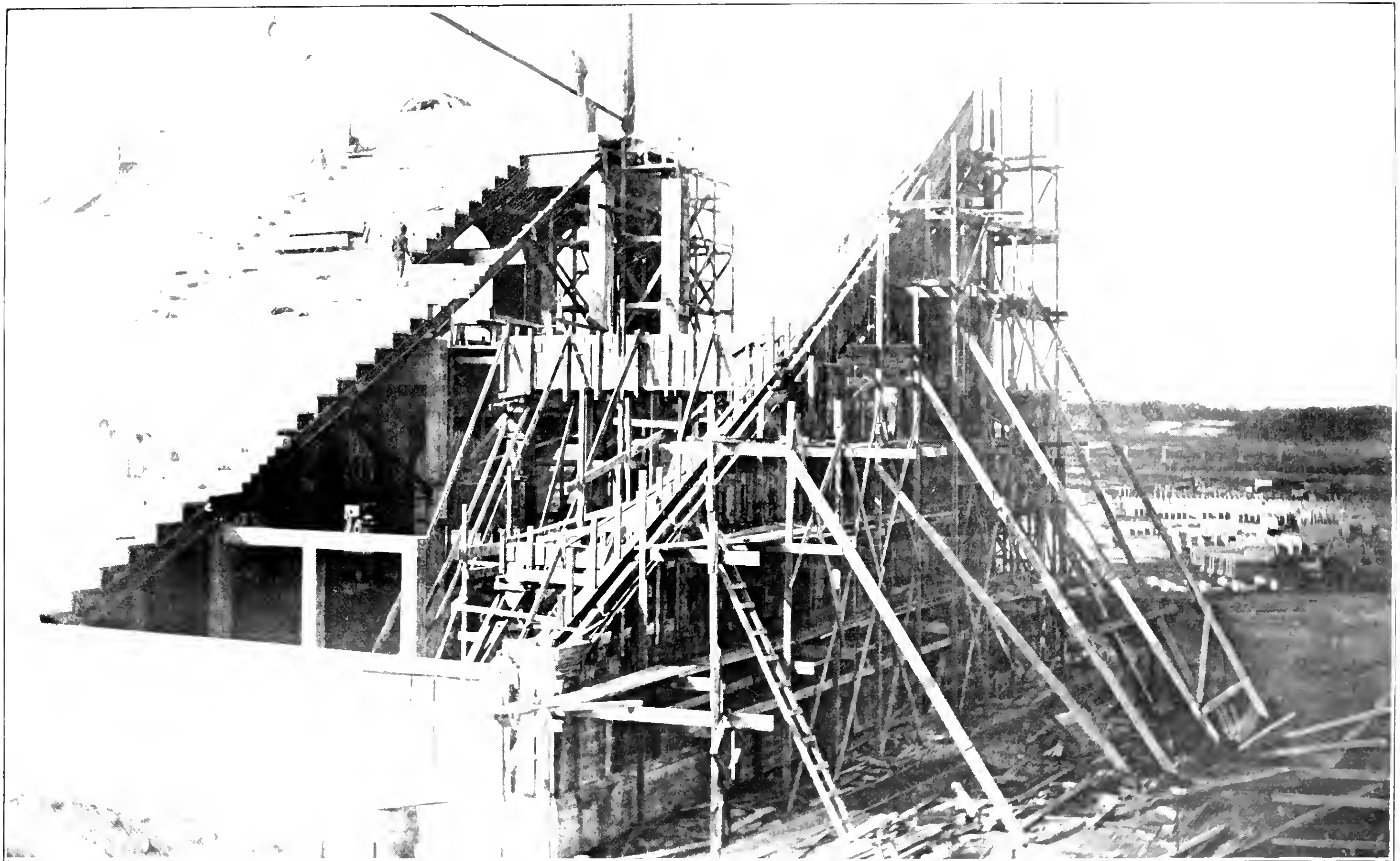
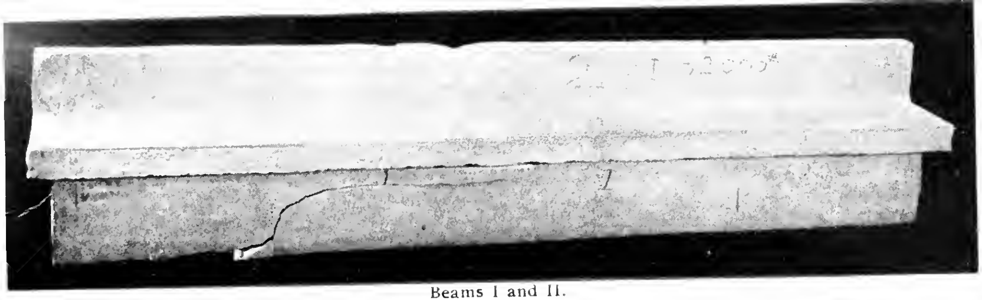
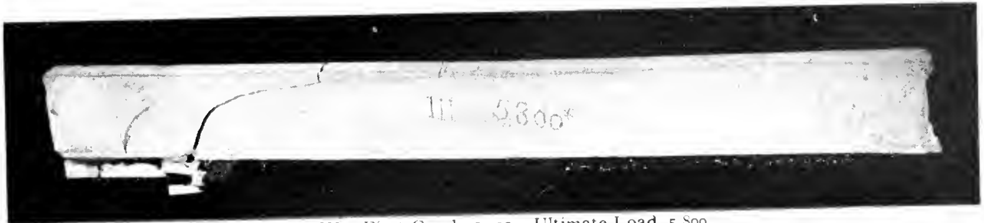


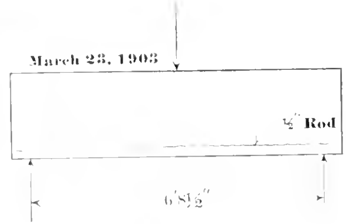
FIG. 9. FORMS FOR END WALL OF WEST WING OF STADIUM. IN THE MIDDLE DISTANCE SEAT SLABS READY FOR SETTING.

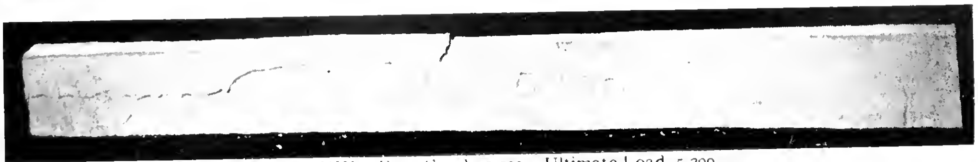


Beams I and II.

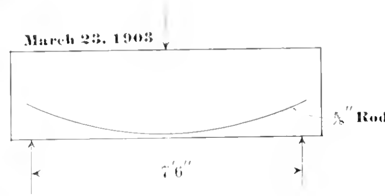


Beam III. First Crack, 1,500. Ultimate Load, 5,800.

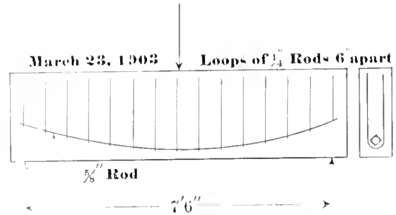




Beam VIII. First Crack, 1,500. Ultimate Load, 5,200.



Beam IX. First Crack, 2,540. Ultimate Load, 6,900.



All Beams made of 1 part Saylor's Portland Cement and 2½ parts Roxbury Pudding Stone Dust. January 29, 1903.

Fig. 10. Results of some of the Beam Tests for the Stadium.

and one-half parts crusher-dust), of fair age and, being cast from a fluid mixture in a sand mold, there was little likelihood of important variation in the quality of the concrete.

DISCUSSION.*

Prof. Charles L. Norton, Massachusetts Institute of Technology.—Since the publication of Report No. IV of the Insurance Engineering Experiment Station, in which was given an account of some laboratory experiments which showed the great degree of protection afforded structural steel by Portland cement concretes, the experiments have been carried on continuously.

All the early tests which were carried out on perfectly clean steel have now been repeated on specimens in all degrees of initial corrosion, with the same results as shown in the case of the chemically clean steel. Doubt existed in the minds of some engineers as to whether the results as found with clean steel would apply to rusty or dirty steel. The method adopted in the early test was to imbed the specimens in blocks of concrete about 3 x 3 x 8 inches, allow them to set under ordinary conditions and then expose them to changing conditions of warmth, moisture and to carbon dioxide, with traces of sulphurous gases and ammonia. Under these conditions unprotected steel vanished into a streak of rust, but protected by an inch or more of sound Portland cement concrete the clean steel was absolutely unchanged. We can now state further, that this same protection is afforded any ordinary structural steel of that degree of cleanliness likely to be found in use for building.

The origin of many of the specimens was rather obscure, as the more corroded ones were taken from scrap heaps of steel works, many having been exposed to the weather for several years. Some had been in buildings as part of the structure, some in salt water, some in fresh water, some in damp ground and the rest exposed to air under various conditions of dampness. The degree of rust on the specimens varied greatly, from a light yellowish stain to a scale more than $\frac{1}{8}$ inch in thickness.

The specimens were first cut to a size such that their length was not far from 3 inches and their width about 1 inch. They were of all thicknesses from $\frac{1}{50}$ inch to $1\frac{1}{4}$ inches. Some were cut dry, some in water, some with the mill fed with oil, and some of those cut with oil were cleaned with gasoline and others with alkaline solutions, while a third part was left more or less oily. It was

* Manuscript received April 1, 1904.—Secretary, Ass'n of Eng. Socs.

intended that the specimens should include everything met with in regular practice.

Each specimen was stamped and the blows of the steel stamp were sufficient to loosen any rust or scale that was not firmly attached, and a vigorous brushing with a soft wire brush removed any loose dust. Each piece was next weighed, and then calipered at several points, and incorporated in a block, or brick, of concrete, sufficiently large to cover it everywhere to a depth of $1\frac{1}{2}$ inches. The mixture was one part cement, two and one-half parts sand and five parts broken stone in some cases, and one part cement, three parts sand and six parts cinders in others. The cements used were Alpha, Lehigh and Alsen, and care was taken in selecting the sand and stone. The latter was of such size as to pass a 1-inch mesh. The concretes were allowed to set twenty-four hours in air and seven days in water, and were then divided into three groups, one being set out-of-doors, one stored in a damp and odorous basement underground and the third being treated in the "corroders" or steam and carbon dioxide tanks. These galvanized iron tanks were supplied intermittently with steam, hot water, moist air, dry air and quite continuously with carbon dioxide for periods of from one to three months. There were a number of specimens which were further exposed in tide water, in sewers, over furnaces, with constant contact of furnace gases.

After varying lapses of time from one to three months for the specimens in the "corroders," and from one to nine for the others, the specimens were broken out of the briquettes, cleaned by brushing and weighed and calipered. Not one specimen had shown any sensible change in weight or dimension, except where the concrete had been poorly applied. Some specimens were purposely bedded in very dry concrete, and some in concrete partly set, and many of these were not well covered and the steel was seriously attacked where there were voids or cracks. Of the hundreds of specimens of rusty steel examined not one which had a continuous, unbroken coating of concrete gained or lost anything in volume or weight by treatment which caused the practical destruction of some of the unprotected specimens. If loss by corrosion as great as $\frac{1}{1000}$ of the loss occurring with the unprotected specimens had been experienced in the case of the protected pieces it would have readily been noted.

It would therefore seem that if we admit that from a severe trial of a short duration we may judge relatively of the effects of the less severe but longer test of time, it cannot be questioned that structural steel is safe from corrosion if incased in a sound sheet of good concrete, at least for a period of years so long as to make the

subject of more interest to our great-grandchildren's children than to us. We know that bare steel does not rust and fall down over night, and that much of the steel standing has been bare of everything that could protect it, for long years, and it seems to me beyond question that steel properly covered in concrete may well be expected to last far longer than the changes in our cities will allow any building to remain.

There is one limitation to the whole question, that is the possibility of getting the steel properly incased in concrete. Many engineers will have nothing to do with concrete because of the difficulty in getting "sound" work. This is especially true of cinder-concrete, where the porous nature of the cinders has led to much dry concrete and many voids and much corrosion. I feel that nothing in this whole subject has been more misunderstood than the action of cinder-concrete. We usually hear that it contains much sulphur and this causes corrosion. Sulphur might, if present, were it not for the presence of the strongly alkaline cement; but with that present the corrosion of steel by the sulphur of cinders in a sound Portland concrete is the veriest myth, and as a matter of fact the ordinary cinders, classed as steam cinders, contain only a very small amount of sulphur. There can be no question that cinder-concrete has rusted great quantities of steel, not because of its sulphur, but because it was mixed too dry, through the action of the cinders in absorbing moisture, and that it contained, therefore, voids; and, secondly, because in addition the cinders often contain oxide of iron which, when not coated over with the cement by thorough wet mixing, causes the rusting of any steel which it touches.

There is one cure and only one, mix wet and mix well. With this precaution I would trust cinder-concrete quite as quickly as stone-concrete in the matter of corrosion. It has been suggested that steel which has been rusted to a slight depth becomes protected by this coating from further rusting. Nothing could be further from the truth. A large number of specimens were rusted by repeated alternate wetting and drying to see if they finally reached a constant condition. Instead of doing this, they all showed an irregular but persistent loss in weight, on further rusting, until some had practically been washed away.

The increasing use of steel of small dimension in floors and roofs, twisted rods, expanded metal, etc., has caused some question as to the advisability of their use in view of the possible great effects of corrosion, as compared with the effects of corrosion on larger members, but with sound concrete of a thickness of about 1½

inches between the steel and the weather I do not question the durability of these lighter members.

The destruction caused to steelwork by rust is certainly not more appalling in most instances, at least, than that caused by electrolysis. The action here is more apt to be local, and hence more dangerous, in that inspection or protection of other parts of a structure will not indicate or prevent impending disaster to the one member which may serve as the point of departure of the escaping electric current. No satisfactory treatment other than some sort of waterproofing has appeared to be successful, and study of this matter is going on at present in many places. It is a problem for the chemist rather than for the engineer.

The next step in this research is to find out in the same general way the degree of protection afforded by paint, and, second, by brick and tile work. This is now under way, and the rapidity with which the "corroders" destroy some paints is such that a report on this subject may be looked for in the near future.

The investigation of the relative efficiency of different paints as a protective coating for structural steel being now under way, it is desired that all kinds of paint be submitted to our test of exposure to varying conditions. To this end we invite all dealers and manufacturers of paint, for this purpose, to send samples to the amount of 1 gallon to Prof. C. L. Norton, Room 4, Walker Building, Massachusetts Institute of Technology, with any directions for applying the paints to either clean or ordinarily rusty steel. The results of these tests will not be published without the consent of the persons submitting the paint to test.

Some pieces of steel will, after coating with the paint under test, be submitted to various corrosive influences; and the details of the exposure being such as will correspond in nature to the actual exposure of structural steel, but of an intensified degree, it is believed that relative results may be arrived at in a reasonably short time in this way.

Prof. Gaetano Lanza.—I have been asked to tell you about some experiments upon reinforced concrete beams and columns, made by some of my students at the Massachusetts Institute of Technology, for their graduating theses; and notwithstanding the fact that an account of these experiments has been published in a recent number of the *Transactions of the American Society of Civil Engineers*,* it has still been thought worth while to have the story told here again.

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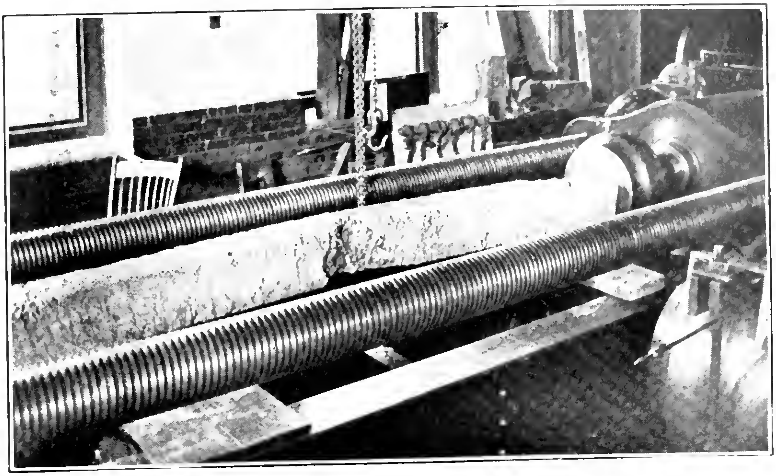
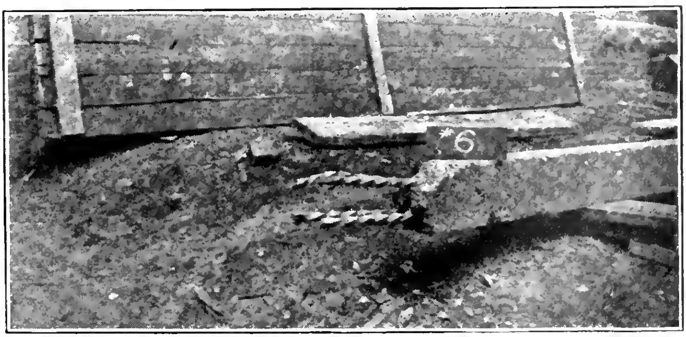
* Vol. L, pages 483 to 485, in discussion of a paper by Myron S. Falk, entitled "Notes on the Coefficient of Elasticity of Concrete and Mortar Beams During Flexure."



Beam No. 3.



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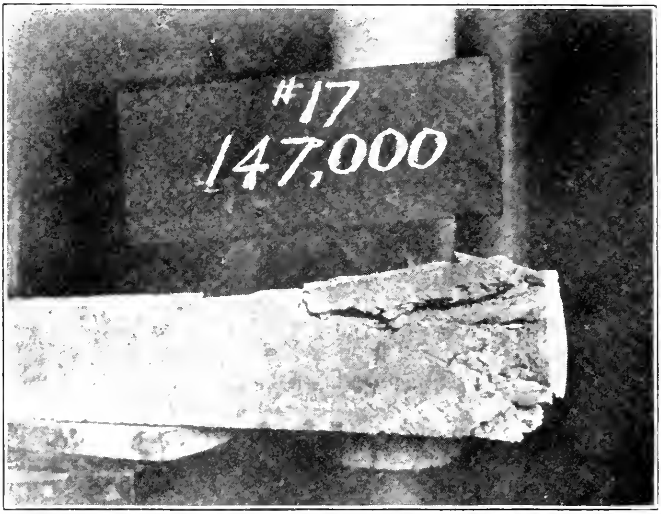

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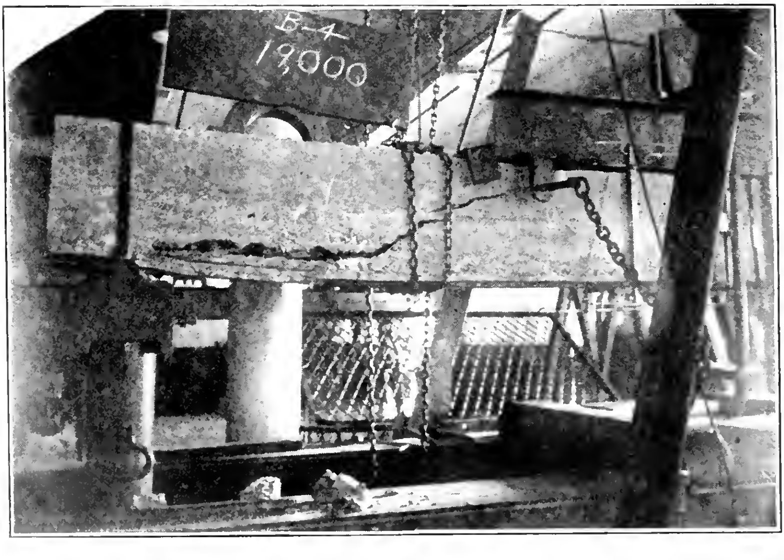
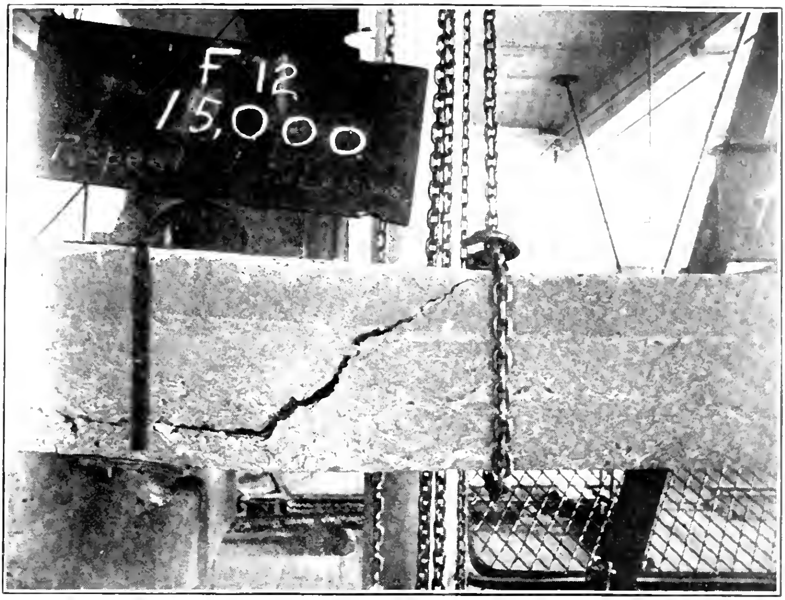
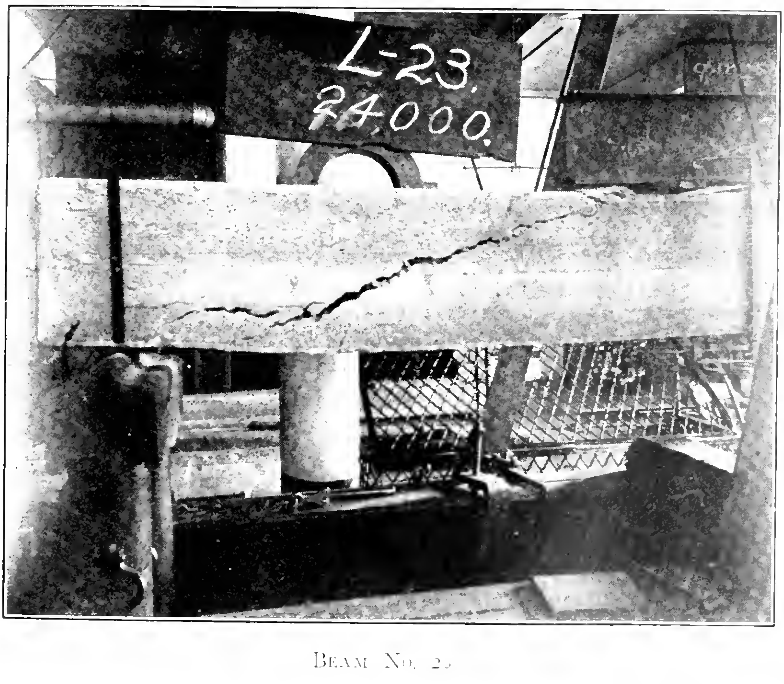


Beam No. 18.



Beam No. 25.



Beam No. 2[illegible]

The following is a list of the specimens tested, viz: One plain concrete beam, 8 x 12 inches x 11 feet span. Twenty-six reinforced concrete beams, 8 x 12 inches x 11 feet span. Fourteen reinforced concrete columns, 8 x 8 inches, of which four were 6 feet long, four 12 feet long and four 17 feet feet long. Seven reinforced concrete columns, 10 x 10 inches, of which two were 6 feet long, four 12 feet long and one 17 feet long. Seven plain concrete columns, 8 x 8 inches and 5 feet long. The concrete was made of one part by volume of Portland cement (Star brand), three parts by volume of sharp, clean and coarse sand from Newburyport, Mass., four parts by volume of trap rock from Somerville, Mass., which would pass a 1-inch ring sieve and two parts by volume of the same kind of rock which would pass a $\frac{1}{2}$-inch ring sieve; the quantity of water used was from 6 to $7\frac{1}{2}$ per cent. by weight. The steel used had a tensile strength varying from 56,000 to 63,000 pounds per square inch, and when twisted about one-third more.

Before planning the series of columns I read carefully the work of Mr. Considère, who, in his Beton fretté, used light vertical rods, $\frac{3}{8}$ of an inch or less square, placed near the outside of the columns, the entire set of vertical rods being surrounded by a wire wound in spiral form and extending throughout the length of the column. The buckling of the vertical rods seemed to furnish the greatest difficulty in his case, and such a result would naturally be expected, in view of the facts stated above.

It seemed better, therefore, to plan this series differently, no spiral reinforcement being used in any of the columns; and accordingly, some of them were built with one reinforcing rod, placed in the center of the section, and others with four rods, placed, respectively, at the middle points of the four half diagonals of the section. The rods in the 8 x 8-inch columns terminated $\frac{1}{2}$ inch from each end of the column, while in the case of the 10 x 10-inch columns the ends of these rods were flush with the ends of the columns. The table of results follows:

REINFORCED COLUMNS.

Number.	Distinguishing Mark.	Age, in Days	Area of Section, in sq inches.	Length in Feet.	Number of Rods.	Side of Square Rod in inches.	Plain P, or Twisted T.	Actual Breaking Load in lbs.	Value of P in Formula: $P=f(A_1+rA_2)$*	MANNER OF FAILURE.
1	1	30	64	17	1	1	P.	107,000	125,000	Crushed at end.
2	2	30	64	17	1	1	T.	127,000	125,000	Buckled first, then crushed at end.
3	7	29	64	12	1	1	P.	100,000	125,000	Buckled first, then crushed at end.
4	8	28	64	12	1	1	T.	126,000	125,000	Crushed at end. Poorly made. Crushed portion cut off; the rest bore 156,000 lbs. at 40 days.
5	9	32	64	6	1	1	P.	138,000	125,000	Crushed at middle, then sheared off along the rod to the end.
6	10	31	64	6	1	1	T.	133,000	125,000	Crushed at end.
7	3	31	64	17	1	1¼	P.	136,000	132,000	Crushed at end, shearing obliquely.
8	4	35	64	17	1	1¼	T.	154,000	132,000	Crushed at end, breaking off 3 feet.
9	5	35	64	17	4	¾	P.	182,000	140,000	Crushed at end.
10	6	34	64	17	4	¾	T.	167,000	140,000	Crushed at end; concrete rather poor and rough at that end.
11	17	31	64	12	4	¾	T.	147,000	140,000	Crushed and split open at end.
12	18	32	64	12	4	¾	P.	153,000	140,000	Crushed and split open at end.
13	15	29	64	6	4	1	T.	158,000	162,000	Crushed and split open at end.
14	16	31	64	6	4	1	P.	244,000	162,000	Crushed at end.
15	25	35	100	17	1	1	P.	215,000	188,000	Broke off clean for 3 or 4 feet at end.
16	26	35	100	6	1	1	P.	200,000	188,000	Sheared diagonally at end.
17	42	45	100	6	1	1	T.	228,000	188,000	Sheared diagonally at end, and broke back for half the length.
18	35	31	100	12	1	1¼	T.	262,000	194,500	Sheared diagonally near end.
19	36	29	100	12	1	1¼	P.	257,000	194,500	Crushed at end.
20	33	28	100	12	4	¾	T.	300,000*	203,000	Did not break; exceeded capacity of machine.
21	34	29	100	12	4	¾	P.	274,000	203,000	Crushed at end. Wedge-shaped piece forced in between rods.

* This is not the breaking load.

If we let

P = total load on the column,

A_1 = area of section of concrete,

A_2 = area of section of steel,

E_1 = modulus of elasticity of the concrete,

E_2 = modulus of elasticity of the steel,

$r = \frac{E_2}{E_1}$,

f = stress per square inch in the concrete,

then is the formula $P = f\ (A_1 + rA_2)$ deduced upon the assumption that the stress per square inch coming on the steel bears to the stress per square inch coming on the concrete the same ratio as the modulus of elasticity of the steel bears to the modulus of elasticity of the concrete, which ratio was, in this case, 8.23.

The formula is, of course, true only when the load is such as does not strain any portion beyond the elastic limit. Inasmuch, however, as it has been employed, more or less, to compute the breaking load, by using for f the crushing strength per square inch of the concrete, the values of P have been computed from this formula, using $E_2 = 28{,}000{,}000$, $E_1 = 3{,}400{,}000$ and $f = 1750$ pounds per square inch, in order that the reader may be able to compare them with the actual breaking loads. A perusal of the results will make it evident that a part of the load is borne by the steel and a part by the concrete.

The manner of failure was, generally, crushing at the ends, only two having failed by buckling, one of which was 12 feet long and one 17 feet long. Sometimes the ends sheared diagonally.

The fractures of Nos. 3, 10 and 11 are shown in the cuts.

In the case of the beams, the steel rods extended longitudinally throughout their lengths, those in the lower part having the centers of their cross-sections at the ends of the beams, 2 inches from the bottom, with a sag at the middle from $\frac{1}{8}$ to $\frac{3}{16}$ inch, except in beams Nos. 12, 13 and 14, where the lower rods were $2\frac{1}{2}$ inches from the bottom, at the ends, with a sag of from $\frac{3}{8}$ to $\frac{1}{2}$ inch. In beams Nos. 12 and 13 there were, on each side of the middle, eight pieces of $\frac{1}{4}$-inch twisted wire bent in the $\sqcup$ form inclosing the rods. In beam No. 12 these $\sqcup$ shaped pieces were inclined at 45 degrees to the depth of the beam, whereas in beam No. 13 they were vertical. In beam No. 14 the wire pieces were in the form of a rectangle inclosing all four rods.

Beams Nos. 26 and 27 each contained, in addition to their reinforcing rods, a vertical layer of expanded metal, extending throughout their length and height.

The tests of these five beams were made at the suggestion of Mr. L. C. Wason, for the purpose of studying the effect of these different arrangements upon the apparent tendency of the beams to break by longitudinal shearing. See table of results on following page.

All the fractures except Nos. 1, 2, 3, 4, 19, 20 and 21 were of the following general character, viz: a longitudinal shearing break, at, or a little above, the reinforcing bar, and, in addition, a break extending diagonally (often at an inclination of about 45 degrees) upward toward the center. The point where this diagonal break joined the top of the beam was sometimes at the point of application of the load and sometimes near it.

The fractures of Nos. 18, 25 and 26 are shown in the cuts.

I do not intend to discuss the various methods proposed for calculating the strength of such beams, and it seems to me that before we can feel sure of the assumptions made in deducing them we need to prove or disprove them experimentally.

While I have been interested in hearing Professor Johnson describe the methods pursued by him, *i. e.*, those of Professor Hatt, I will only say that while Professor Hatt claims that the modulus of elasticity for tension of concrete is one-half that for compression, more conclusive experiments will be necessary before I can feel sure of the correctness of this conclusion.

Indeed, the determination of the modulus of elasticity of concrete in tension presents a great deal of difficulty, but it forms a most important factor in any determination of the proper mode of calculating the strength of such beams.

Many methods are proposed by different people for inserting steel pieces in such a way as to prevent the kind of fracture most common in such beams and which has been already described.

Of the methods tried in these series of beams none seems to have prevented the above-stated method of fracture, and hence I feel very doubtful about accepting any proposed method as effective unless it has been proved to be so by experiments made on a full-size scale.

It should be added that the planning of the series and the work of testing and figuring up the results was performed, under the writer's direction, by the following gentlemen for their graduating theses, viz: Mr. Edward Seaver, '01, on beams; Messrs. G. M. Harris and G. B. Wood, '03, on columns, and Messrs. W. H. Adams and I. F. Atwood, '03, on beams. Moreover, these series of tests were rendered possible through the kindness of Mr. L. C. Wason, '91, President of the Aberthaw Construction Company, who furnished all the materials and built all the specimens.

BEAMS.

Number of Beam.	Age, in Days.	Bars near Bottom: Number.	Bars near Bottom: Side of, sq. Inches.	Bars near Bottom: Plain P or Twisted T.	Bars near Top: Number.	Bars near Top: Side of, sq. Inches.	Bars near Top: Plain P or Twisted T.	Manner of Loading at Time of Fracture.	Weight of Beam, in Pounds.	Breaking Load, exclusive of Weight of Beam, in Pounds	Maximum Bending Moment at Fracture, in Inch-Pounds.	REMARKS.
1	40	......	......	......	......	......	......	Center.	1,198	1,302	62,733	Vertical break near middle of span.
2	40	1	1/4	T.	......	......	......	"	1,200	1,300	62,700	Vertical break at middle. Bar drew down to 1/8 inch and broke.
3	39	1	1/2	T.	......	......	......	At two points.	1,205	10,095	241,973	Vertical break at one point of application of load. Bar drew down to 1/4 inch and broke.
4	38	1	3/4	T.	......	......	......	Center.	1,160	13,680	470,580	Concrete crushed on top.
5	50	1	7/8	T.	......	......	......	"	1,290	14,710	506,715	
6	50	1	1	T.	......	......	......	"	1,204	15,796	541,134	
7	41	1	1 1/4	T.	......	......	......	"	1,195	12,805	442,283	
8	41	2	1	T	......	......	......	"	1,240	18,760	639,540	
9	42	2	1 1/4	T.	......	......	......	"	1,274	23,105	783,486	
10	42	2	1 1/4	T.	1	1/2	T.	"	1,279	21,105	717,569	
11	45	2	1 1/4	T.	2	3/4	T.	"	1,294	23,105	783,816	
12	30	2	1 1/4	T.	......	......	......	At two points.	1,282	24,200	553,553	
13	31	2	1 1/4	T.	......	......	......	" "	1,292	29,200	663,718	
14	30	2	1 1/4	T.	2	3/4	T.	" "	1,341	24,200	554,527	
15	53	1	1	P.	......	......	......	" "	1,292	15,250	356,818	
16	49	1	1	T.	......	......	......	" "	1,211	16,500	382,982	
17	43	2	3/4	P.	......	......	......	" "	1,271	15,950	371,872	
18	40	2	3/4	T.	......	......	......	" "	1,200	19,000	437,800	
19	35	4	1/2	P.	......	......	......	" "	1,261	17,500	378,065	Beam had a crack about 18 inches from center. Failed at this vertical crack.
20	33	4	1/2	T.	......	......	......	" "	1,213	20,000	433,329	Failed by longitudinal shearing.
21	57	1	1 1/4	P.	......	......	......	" "	1,213	12,500	295,015	Vertical break at one point of application of load. Rod pulled through. Concrete was not sufficiently packed in making.
22	54	2	7/8	T.	......	......	......	" "	1,248	22,250	510,092	
23	57	2	7/8	P.	......	......	......	" "	1,221	20,250	465,647	Beam cracked, in handling, 22 inches from center. Failed by longitudinal shearing.
24	47	4	5/8	T.	......	......	......	" "	1,203	19,250	443,350	
25	50	4	5/8	P.	......	......	......	" "	1,192	15,250	355,168	
26	40	2	3/4	T.	......	......	......	" "	1,215	24,250	553,548	
27	49	1	1	T.	......	......	......	" "	1,222	21,750	498,663	

PROF. ARTHUR W. FRENCH, Worcester Polytechnic Institute.—In planning a concrete-steel building, before reaching the details, careful consideration of the peculiarities of concrete-steel combinations may well decide many important features in the layout of walls, columns and beams.

With the available space below the seats of the Stadium, it may be a question whether the girders of 24 feet 9 inches span, carrying heavy concentrated loads, might economically have been replaced by shorter spans and a greater number of columns.

I can but feel a bit of regret that such a monumental structure was not planned to avoid all exposed structural steel, and that reinforced concrete, which forms so large a part of the Stadium, was not used exclusively.

The first thing that strikes one as peculiar in the construction of concrete work is the fact that the structure cannot be built as a monolith; that it is cut up, as Professor Johnson has shown—cut up into sections to provide for expansion and for possible cracks. This leads to many complications. The day's work is stopped at places where, on the plans, it would look as though filling up with concrete might go on; the day's work at certain points is limited, and the work must be spread over considerable areas. If we dared to build such structures without joints it would greatly simplify the matter.

The spacing of the steel in the columns offers some difficulties, especially with the hoops. The four rods in the corners of the columns, without the hoops, are very easy to keep in place, and to keep exactly at the right distance from the corner.

The minute the hoops are introduced we must have a free chance, from the top to the bottom, to drop the hoop over the four corner rods, and it was with some fear of having them show through the concrete that I placed them as shown. However, I think none of them have shown through. The packing of the steel in the beams has been well illustrated; and the introduction of stay rods, for the purpose of taking up the shearing, adds to the difficulties of placing the concrete.

One feature of the concreting, very pleasing to me, was the agreement, between Professor Johnson and the Aberthaw Company, as to the consistency of the concrete. Being a firm believer in wet concrete, I was delighted to have a chance to use it.

Those columns, 14, 16 and 24 inches square and 25 feet in height, we found it would be impracticable to fill, except from one stage at the top. If that concrete had been put in dry, or of the consistency advocated by some in the past, it would have been diffi-

cult to produce smooth or solid work. It was put in wet enough to spade easily into place, the spades being worked continuously, usually by two men. I think those of you who have seen the work have noticed that it shows full, without voids. Experiments show that it is equally solid throughout.

As to the effect of consistency upon the strength of the concrete, there may be a difference of opinion. I believe that, after a lapse of time, it will compare favorably with any drier mixture.

The work at the Stadium was a summer's vacation for me, and one leading to very pleasant connections with the supervisors and those in charge at Harvard. My particular interest was in the study how to place that work. The plan adopted was, I think, fairly satisfactory, as shown by the time taken to bring the work to such a state of completion that it could be used. The structure is 50 to 60 feet in height, and has various heights. Except the 16-foot promenades there were no level landings upon which to place derricks, and the first question was to design the handling plant. We adopted towers and cableways, as you noticed on the slides. They have their limitations, but, on the whole, were fairly satisfactory. The towers were rolled along on tracks and placed wherever the cables could be used to the best advantage. The casting floor of the foundry was served with cranes and railroad tracks, as was clearly shown.

The subject of concreting with steel reinforcement may be made too complicated, so far as theory goes. I am perhaps not competent to judge, but it seems to me the design of the section of a beam will be changed. The variations in the modulus of elasticity in concrete prohibits any fine computation of sections, and I believe it will be, as Professor Johnson has shown, so simplified that any engineer will pick out his concrete-steel beams with something of the confidence he feels in choosing timber, and with similar limitations.

I think there is nothing further I can now add to the discussion. I am glad to acknowledge my indebtedness to the Society and to Professor Johnson for a chance to hear the paper.

Prof. George F. Swain.—We are very much indebted to Professor Johnson for this paper, and I hope it will be published entire, for it contains a great deal of information which is valuable to those who have to do with structures of reinforced concrete.

The matter of shearing in concrete is of much importance, and I wish Professor Johnson had explained a little more in detail how he proportioned his stirrups. As he suggests the analogy between them and the verticals of a truss, I should be glad to know whether

he computed them by taking the longitudinal shear at the neutral axis along a distance equal to the distance between stirrups, deducted from this what the concrete itself would carry, allowing 20 pounds per square inch shearing stress, and then multiplied the difference by the ratio of depth of stirrup to distance between stirrups. The stiffeners in a plate girder might be computed in this manner, though I do not know of this method having ever been followed in design. Indeed, the action of the stirrups, like that of plate-girder stiffeners, must be very uncertain, and the stirrups probably act partly in tension, and to some extent in shearing also. With reference to the shearing strength of the concrete, I note in *Beton und Eisen* for 1903 (Heft II) a rather elaborate discussion of the subject.

With reference to the protection of steel by concrete, foreign authorities claim, as is well known, that rusty steel or iron, if covered with concrete, will lose its rust and become bright. I should like to ask Professor Norton whether he has any experiments which substantiate this. In the East Boston tunnel the steel rods used were cleaned by the sand blast, it being considered best to be on the safe side. Perhaps this precaution was unnecessary.

Professor Norton.—In answer to Professor Swain's question, I would say that, paradoxical as it may seem, with quite a number of specimens, which were coated with what would be called rust (not oxide, but rather hydrate of iron), or rather the beginning of rust, we found the specimens were cleaner after the experiment than before, and that they weighed a little less than when the concrete was put on. The action is small, because we had taken every precaution to treat them as harshly as possible. The weighings were made as carefully as could be done. I have been very chary about making statements on that point. The evidence certainly points to a real formation, on some of the heavier specimens of iron, free of iron hydrate or iron oxide. Whether this formation is of any use or not I do not know. It looks like a black smouch on the iron itself rather than a return to the structural material.

I had commenced to make one hundred or more slabs of cinder- and stone-concrete for one of the construction companies. The results of that investigation not being complete, we have not yet been able to publish it, but one of the things we did find out was that mixing the concrete just as wet as we could mix it, so wet that we had to put waxed paper on the bottom and sides of the mold, and then mixing it just as dry as we could mix it and tamping from above, so that the mixture was solid—that is, well together,—the one was gelatinous; you could have run a shovel in and cut a groove

in it and it would return to its position; while the other was of such rigidity that if you stepped on it the imprint of your heel would remain in it: all were made and the slabs were broken. In the meantime we weighed some of the smaller pieces. We could not find out by breaking or weighing which was mixed wet and which was mixed dry. In breakage, the difference between wet and dry was less than 5 per cent., which was less than would be expected. Some were cinder-concrete and some were stone-concrete. They were of different thicknesses: 2, $2\frac{1}{2}$, 3 inches, etc., to 8 inches, and the sizes of the slabs from 2 x 3 feet to 8 x 10 feet.

Moisture in the mixture seems to aid in making a first-class bond between the concrete and the steel. The metal was imbedded within an inch of the lower surface. Every one of the slabs carried a certain definite load, up to the point of developing a tension crack. The cracks give very ample warning. Some deflected 6 inches before they broke, a very interesting point in view of the question of safety to viewpoints of a building.

We are having a good deal of steel-concrete with corner-tension rods of steel, a most excellent place to put it, from the point of view of strength, but a poor place in case of fire. I have known a concrete structure, built for testing purposes by Professor Lanza and myself, having 1 inch of concrete between the steel and the fire. Then we put it through the New York fire test. It stood it for 3 hours and 40 minutes, and then the posts gradually weakened. The concrete softened and the iron began to pull through. Finally, when the concrete was weakened, the whole thing fell down and was discredited, as it would not have been had there been an inch more of concrete between the steel and the outside of the posts. I would suggest that no work be put up with less than an inch and a half of concrete outside the steel.

W. K. Hatt, Professor of Applied Mechanics, Purdue University (by letter).—The writer has been greatly interested in Professor Johnson's paper, and desires to add something further concerning the design of reinforced concrete beams. Professor Johnson's simple method will, in the opinion of the writer, yield safe and reasonably economical sections. At the present time it is probable that these beams must be designed on the basis of the strength at the point of first crack; but when a knowledge of constants is extended, and the mechanical analysis is simplified, we may hope to design such beams with factors of safety chosen with reference to a point in flexure of these beams corresponding to the yield point in most materials. This point has been called "Point A" in the Load-Deflection Diagrams presented by the writer in the "Proceed-

ings of the American Society for Testing Materials," Vol. II, 1902. One of these diagrams is here reproduced.

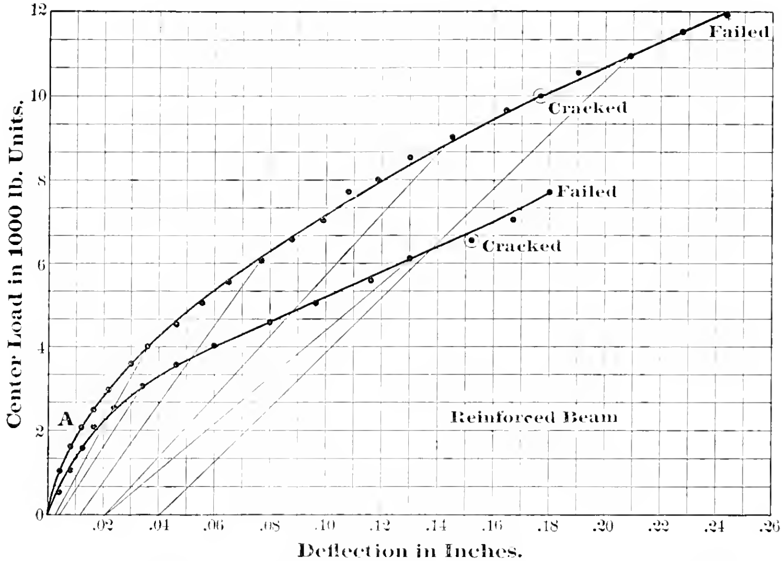


FIG. 1. LOAD-DEFLECTION DIAGRAM OF REINFORCED-CONCRETE BEAM.

Professor Johnson has used the value of 7.5 for the ratio of the modulus of elasticity of steel in tension to the modulus of elasticity of concrete in compression. The writer desires to quote certain results recently obtained in experiments performed in the laboratory for testing materials of Purdue University, which justify the use of this value of the constant. Table I gives the modulus of elasticity, and the strength of both broken stone and gravel-concrete at twenty-eight and ninety days. The limestone was the product of the crusher below 1 inch. The gravel was excellent pit gravel, including sand and pebbles. The concrete was medium wet. The values quoted are based upon tests of thirty-seven compression specimens, involving 202 determinations of the modulus in compression, and on tests of twenty-seven tension specimens, involving seventy-nine determinations of the tension modulus. From these results it appears that the ratio of the modulus of elasticity of concrete in compression to that in tension is nearly unity. The ratio of the modulus of elasticity of the steel in tension to the concrete in compression is as follows:

Stone-concrete ....28 days.		8.8
" " ....90 "		6.6
Average		7.7
Gravel-concrete ....28 days.		8.0
" " ....90 "		6.2
Average		7.1

To add to Professor Johnson's value of the constant K in the formula $M = Kbh^2$, the writer would quote the following Table II,

TABLE I.—MODULUS OF ELASTICITY OF PORTLAND CEMENT CONCRETE.

Kind of Cement.	Concrete Sand.	Broken Stone.	Gravel.	Age.	Compression Modulus.	Tension Modulus.	Ultimate Strength Comp.	Ten.
				Days.	Lbs. per sq. inch.	Lbs. per sq. inch.	Lbs. per sq. inch.	
1	2	5	...	90	4,610,000	5,460,000	2,513	359
1	2	5	...	28	3,350,000	3,800,000	2,290	237
1	...	...	5	90	4,800,000	4,510,000	2,804	290
1	...	...	5	28	4,130,000	4,320,000	2,405	253

TABLE II.—SHOWING VALUE OF K IN FORMULA $M = Kbh^2$ FOR LOADS AT FIRST VISIBLE CRACK IN TENSION.

Beams.		Amount and Depth of Reinforcement.	Age.	K.
STONE with wrought-iron reinforcement.	C. S. Broken Stone. 1-2-4	none	1 month	90
		none	1 week	60
		1% .... 1 inch	1 month	265
		1% .... 2 inch	1 month	195
		1% .... 2 inch	1 week	160
		2% .... 1 inch	1 month	391
		2% .... 2 inch	1 month	240
GRAVEL with steel reinforcement	C. Gravel 1-5	½% .... 1 inch	3 months	161
		1% .... 1 inch	3 months	322
		1% .... 1 inch	1 month	283
		2% .... 1 inch	3 months	526
		2% .... 1 inch	1 month	480

Elastic Limit of Iron = 36,000. Elastic Limit of Steel = 33,300. Materials as in Table I. Units, M (moment) in inch-lbs.; b, h in inches.

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8 x 8 in
beams w
the tens
natural
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strength
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Plate I.

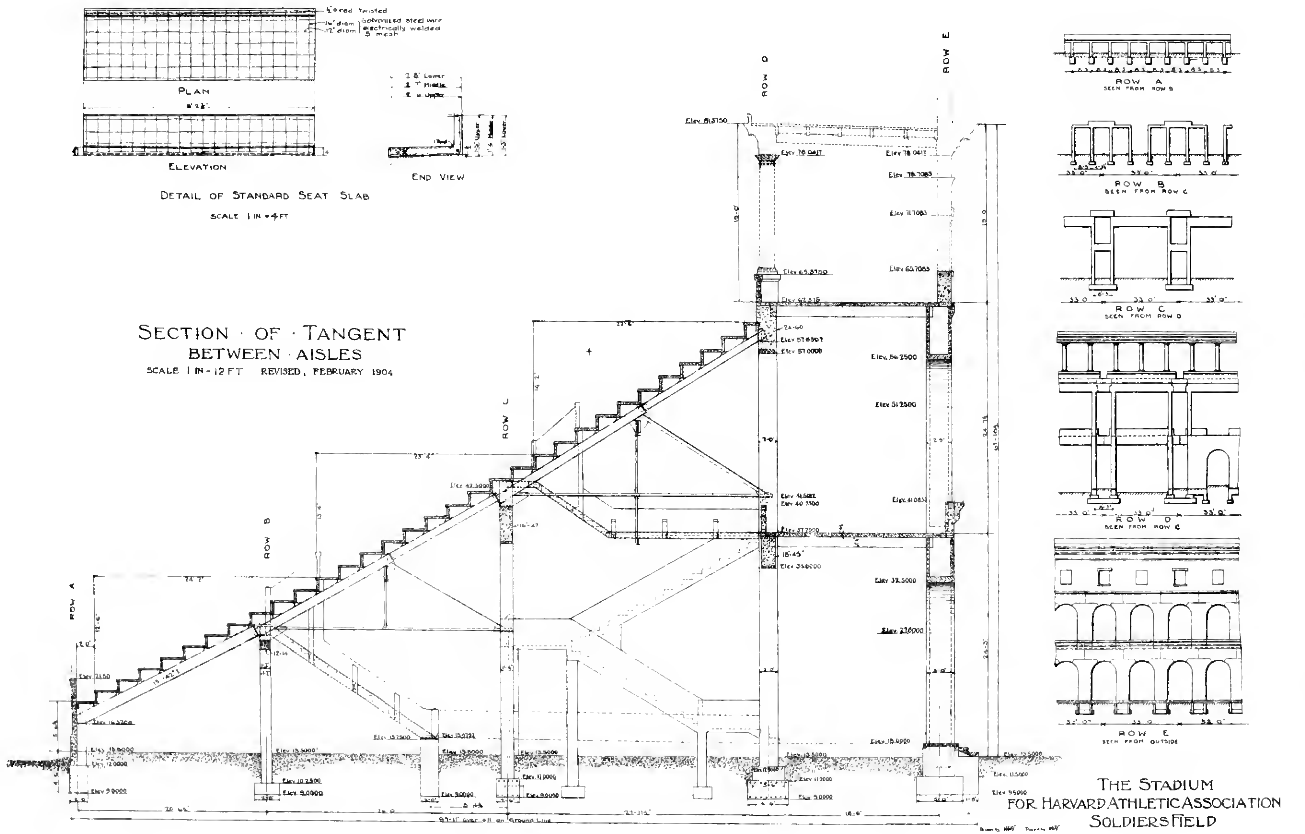
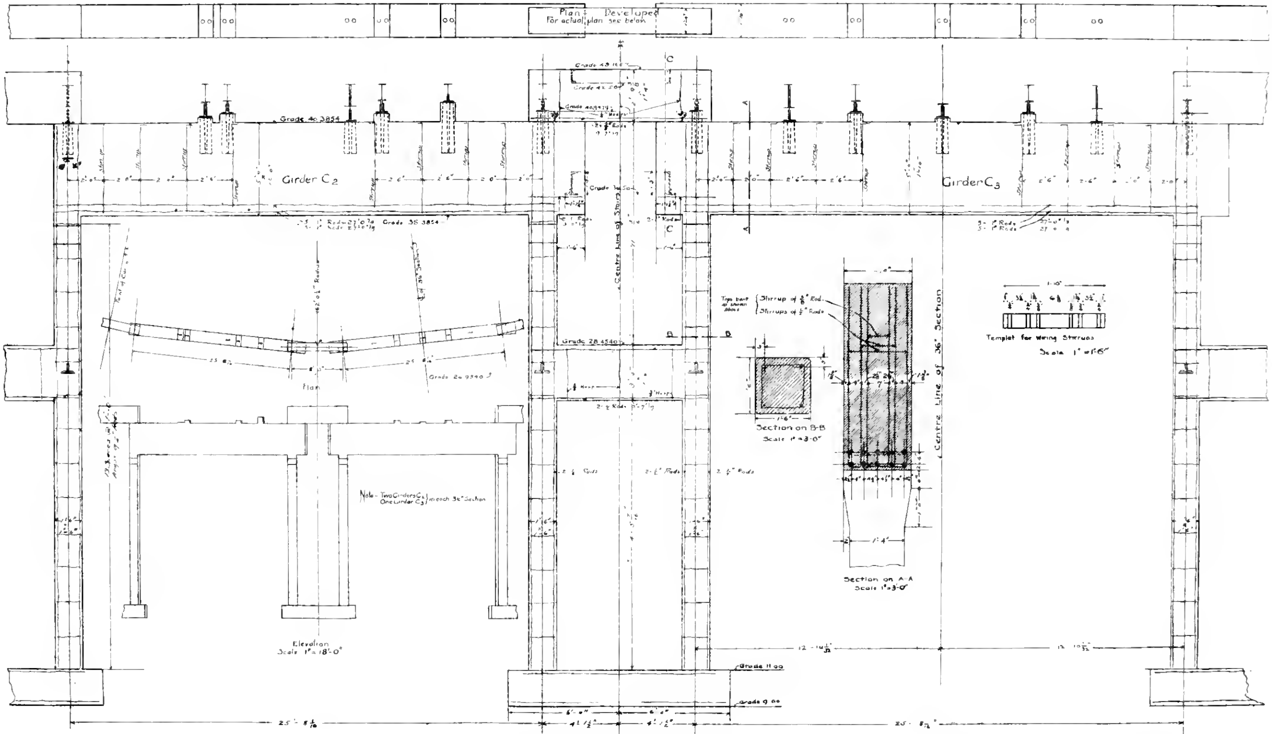

PLAN
ELEVATION
END VIEW
DETAIL OF STANDARD SEAT SLAB
SCALE 1 IN = 4 FT
SECTION · OF · TANGENT
BETWEEN · AISLES
SCALE 1 IN = 12 FT REVISED, FEBRUARY 1904
ROW A
ROW B
ROW C
ROW D
ROW E
ROW A SEEN FROM ROW B
ROW B SEEN FROM ROW C
ROW C SEEN FROM ROW D
ROW D SEEN FROM ROW C
ROW E SEEN FROM OUTSIDE
THE STADIUM
FOR HARVARD ATHLETIC ASSOCIATION
SOLDIERS FIELD

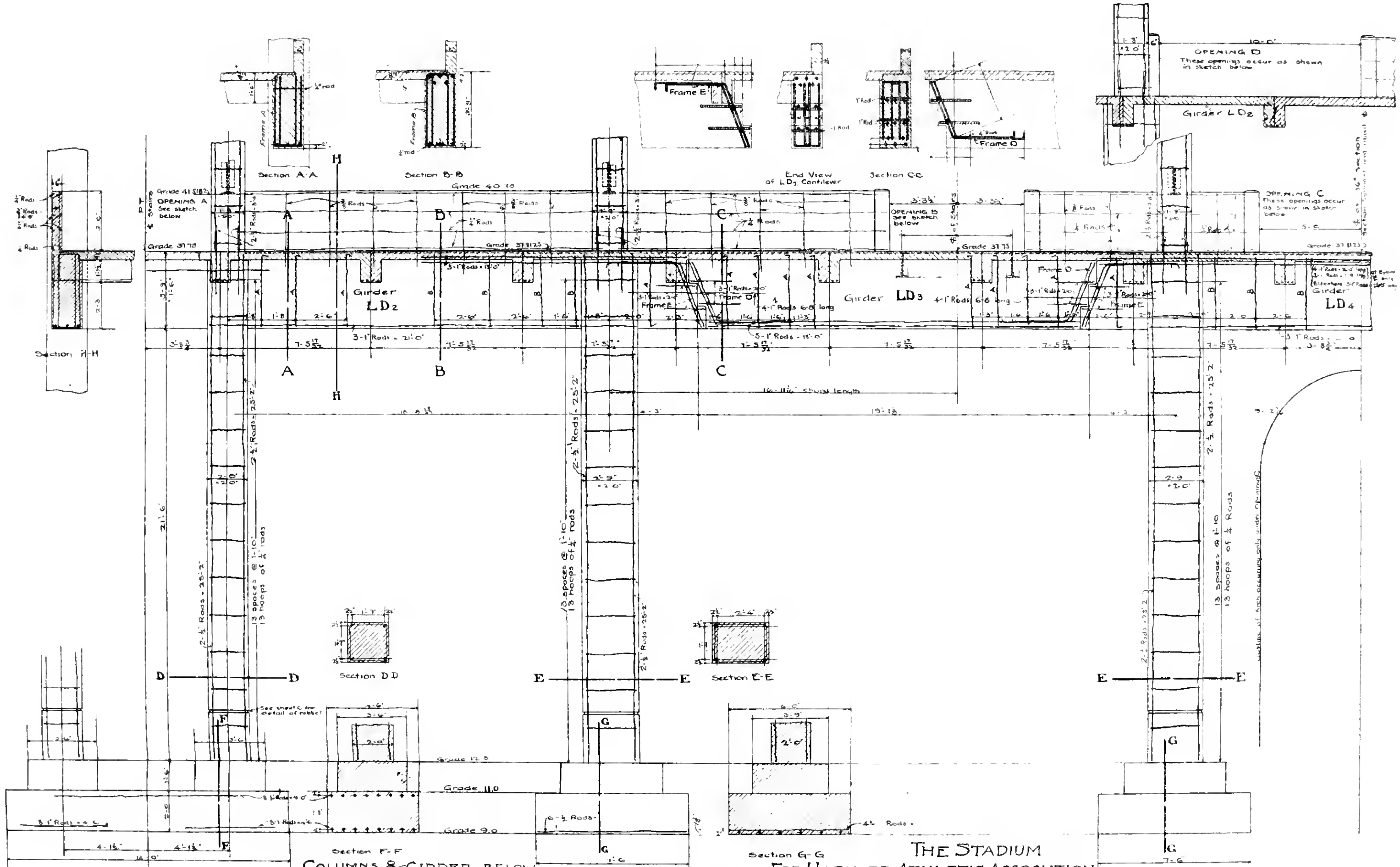
Plate II.



ELEVATION OF COLUMNS - ROW C - CURVE
LOOKING FROM THE FIELD
SCALE 1IN = 12FT

THE STADIUM
FOR HARVARD ATHLETIC ASSOCIATION
SOLDIERS FIELD
Sept 8 1903

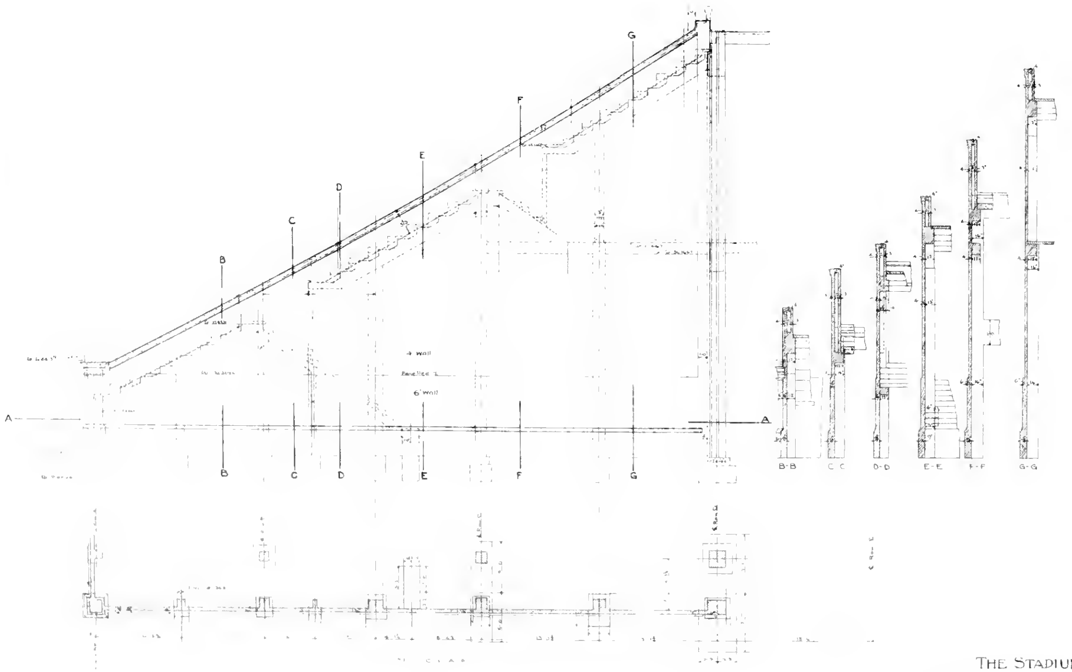
Plate III.



COLUMNS & GIRDER BELOW MEZZANINE FLOOR ROW D - CURVE
LOOKING TOWARDS GRIDIRON.
Sept 12, 1903
SCALE 1 IN = 12 FT.

THE STADIUM
FOR HARVARD ATHLETIC ASSOCIATION
SOLDIERS FIELD

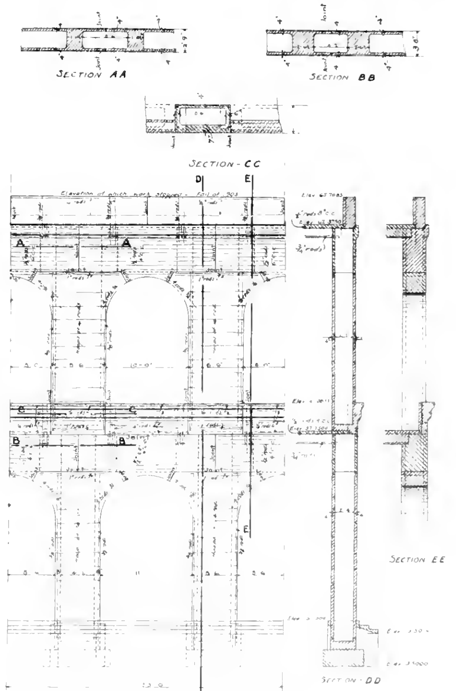
Plate Va.



Elevation of End Wall
Scale October 14 1903

THE STADIUM
FOR HARVARD ATHLETIC ASSOCIATION
SOLDIERS FIELD

Plate Vb.



Portion of Rear Elevation of Row E
Scale 1in=12ft.

METHODS FOR DETERMINING THE EQUATIONS OF EXPERIMENTAL CURVES.

By A. S. Langsdorf, Member of the Engineers' Club of St. Louis.

[Read before the Club April 20, 1904.*]

In the course of many investigations of a physical or engineering nature it becomes necessary, or desirable, to reduce the results of the observations to the form of an equation; or, in other words, to deduce a law sufficiently general to cover the full range of observed data. Methods for the accomplishment of this end are undoubtedly known and used by many engineers, but, singularly enough, little concerning this important subject has appeared in technical publications. The discussion herewith presented is therefore brought forward in the hope that it may be of service to investigators desirous of pushing their work to a definite conclusion.

In many cases the law governing the particular conditions under observation may be known at the start, and, therefore, also the general form of its mathematical expression; the problem then reduces to that of determining the numerical values of the constants of the general equation. But it may, and does, happen that an *a priori* determination of the equation is impossible, and it then becomes necessary to devise an empirical equation to represent the facts. This is essentially an inductive process, the other class of problems mentioned above being only a special case of it. Fortunately, the solution of the general case is much facilitated by the fact that the great majority of physical laws are relatively simple, in consequence of which their mathematical expressions do not involve complicated functions of the variables. In fact, the graphical representations of the equations are almost wholly limited to five groups: (1) The straight line; (2) parabolic curves; (3) hyperbolic curves; (4) logarithmic curves; (5) periodic curves. Of these, the first four only will be considered here.†

In treating any particular case the first step consists of plotting the observed data and classifying the curve geometrically. Some uncertainty as to choice may exist here, for with an arbitrary scale of drawing, curves of the second, third and fourth groups may appear indistinguishable; but judicious reasoning as to the limiting

* Manuscript received April 29, 1904.—Secretary, Ass'n of Eng. Socs.

† For a treatment of periodic curves, see a paper by the author on "A Graphical Method for Analyzing Distorted Alternating Current Waves," *Physical Review*, vol. xii, p. 184.

conditions of the experiment will often furnish a clue not otherwise available—such, for instance, as the presence or absence of asymptotes, the slope of the curve at particular points and other similar considerations. Under the most unfavorable conditions a trial of several typical forms will indicate which is likely to prove the best. When the curve has been tentatively classified, the characteristic equation may be assigned to it, and it then remains to evaluate the constants entering therein.

In order to examine the methods of analysis in detail, each group will be treated separately, and illustrated by more or less specific examples.

THE STRAIGHT LINE.

Suppose that a series of observations of two related variables gives the data which are plotted in Fig 1. The average line through the points is evidently straight, its position being determined by stretching a thread across the paper until the points above and below it balance. The general equation of the line is

$$y = ax + b \qquad (1)$$

Select two points, such as p and q, on the line, and as far apart as possible; they should preferably be taken where the line crosses the intersection of two of the co-ordinate rulings, for greater accuracy in reading. The co-ordinates of p and q must satisfy (1), so that on substituting these values from the figure we have the two simultaneous equations

$$26.5 = 3.5\,a + b$$
$$3.0 = 81.0\,a + b$$

from which $a = -0.303$ and $b = +27.56$, or

$$y = 27.56 - 0.303\,x$$

It is to be observed that this method gives to the final values of a and b the accuracy of the method of least squares. For a and b depend upon the slope and position of the line, which, in turn, depends upon *all* the points plotted; from which it follows that the result is the same as if each observation were weighted. Thus, if through some error of observation, one of the plotted points falls considerably off the average line, the position of the latter will not be appreciably affected thereby, and hence the error will not appear in a and b, as would be the case if the constants were found by direct substitution of observed values in (1).

The case of the straight line has been treated thus fully because the methods for the other cases are such that the final part of

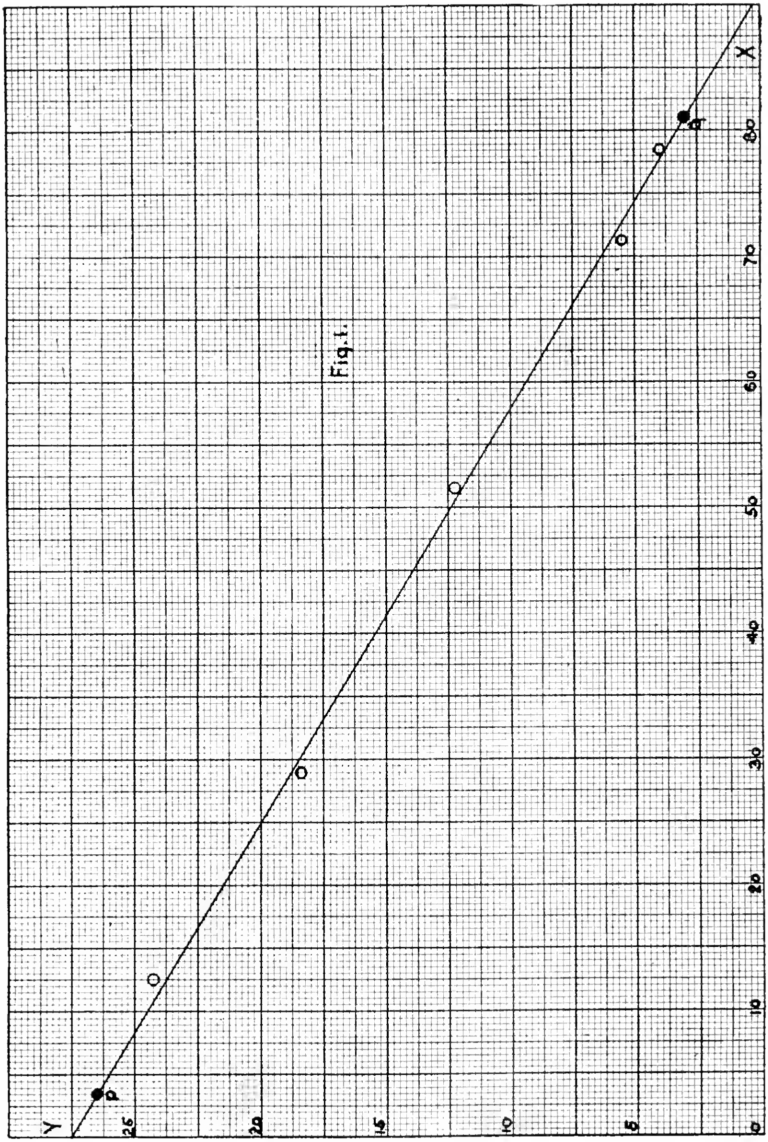


Fig. I.
X
Y
P
Q
0
10
20
30
40
50
60
70
80
5
10
15
20
25

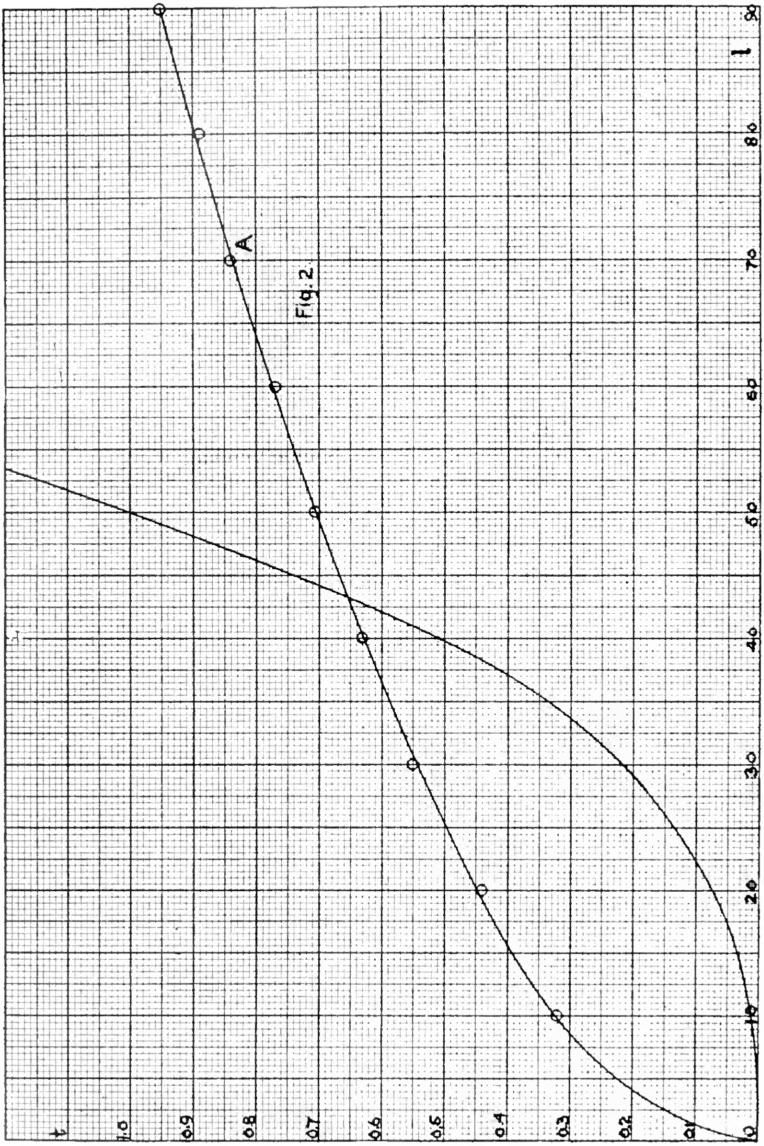


Fig. 2.
A
t
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10
20
30
40
50
60
70
80
90
l

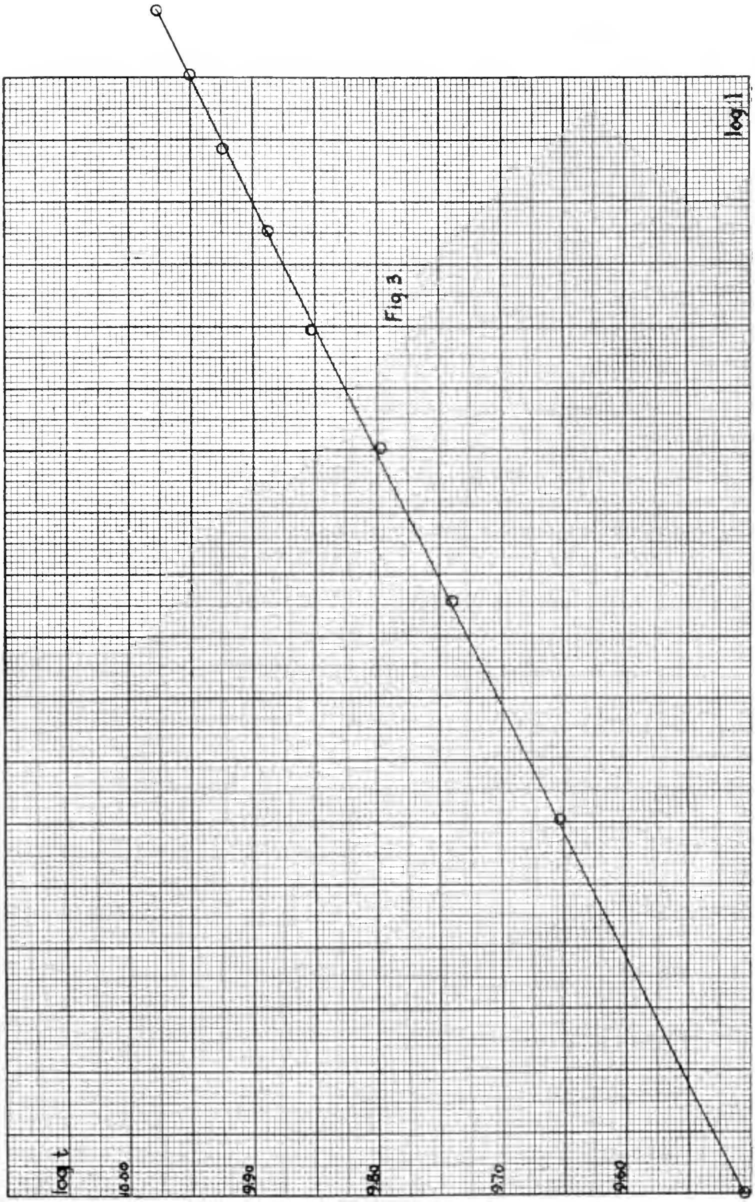


Fig. 3.

each process involves the determination of the constants from a straight line. A due appreciation of the accuracy thus obtained is, therefore, essential.

PARABOLIC CURVES.

The general equation of curves of this class (as encountered in practical work) is

$$y - a = k\,(x - b)^n \qquad (2)$$

the vertex of the curve being at the point (b, a). In Fig. 2 are shown two curves of this class, but in both cases the vertex is at the origin.

The curve will be convex or concave to the axis of X according to whether n is greater or less than unity, respectively.

When the vertex is at the origin, equation (2) becomes

$$y = kx^n \qquad (3)$$

Curve A, for example, has been plotted from the results of an experiment with a simple pendulum, the ordinates being the times of oscillations in seconds, and the abscissas the corresponding lengths in centimeters. Assuming (3) as the form of the equation of A, we may write

$$\log y = \log k + n\log x \qquad (4)$$

If the assumption is correct, then on plotting log y and log x, a straight line should result (as in Fig. 3), since (4) is of the first degree in these variables. This being found to be the case, we may proceed to evaluate log k and n as described under The Straight Line, thus finding the values

$$n = 0.495 \text{ (or nearly } 0.5)$$
$$\log k = 9.011 - 10,\ k = 0.102$$

Therefore,

$$t = 0.102\,\sqrt{l}$$

The agreement with theory is very close, since the actual formula is

$$t = \pi\sqrt{\frac{l}{g}} = 0.1006\sqrt{l}$$

The value of n for curves of this class may be found in another way by virtue of a property possessed by exponential curves. Differentiating (3), we have

$$\frac{dy}{dx} = knx^{n-1} \qquad (5)$$

dividing (3) by (5), and transposing,

$$n = \frac{x}{y}\frac{dy}{dx}$$

but, according to Fig. 4, $\frac{dy}{dx} = \frac{PN}{TN}$, $x = ON$, $y = PN$, therefore,

$$n = \frac{ON}{TN}$$

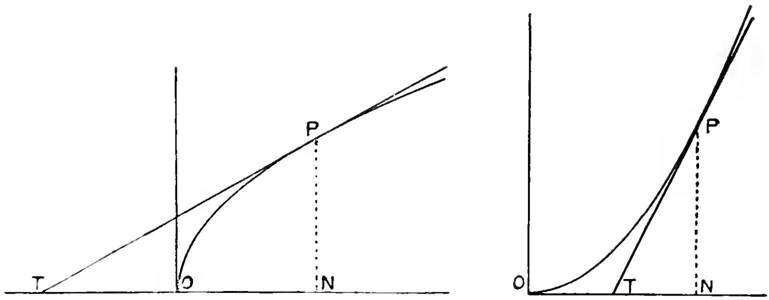


FIG. 4.

That is, n is the ratio of the abscissa of any point of tangency to the corresponding subtangent, provided the vertex is on the axis of X. If, therefore, a number of tangents to the curve are drawn, and this ratio found for each case, an average value of n may be obtained. This method is disadvantageous in that it does not show clearly the truth or falsity of the original assumption concerning the parabolic nature of the curve; this is particularly the case when successive values of n show a slight tendency to deviate regularly from a mean value.

The general case, in which the vertex of the curve is displaced from the origin, is rather more difficult to handle than that discussed above. It will be noted that the characteristic equation (2) contains four constants, at least two of which must be eliminated before the remaining two can be found. Differentiating (2), we have

$$\frac{dy}{dx} = kn\,(x - b)^{n-1} \qquad (6)$$

which disposes of one constant. If now b can be evaluated, equation (6) will take the form

$$y_1 = knx_1^{\,n-1}$$

where

$$y_1 = \frac{dy}{dx}$$

$$x_1 = x - b$$

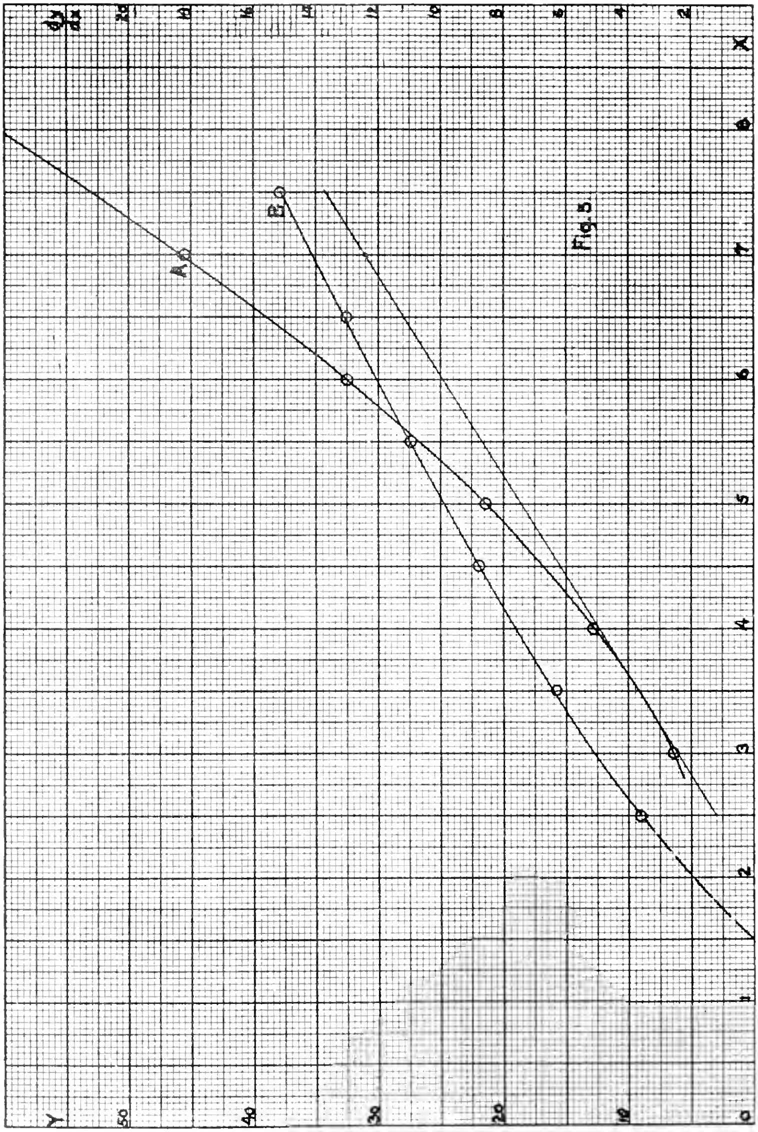


Fig. 5.

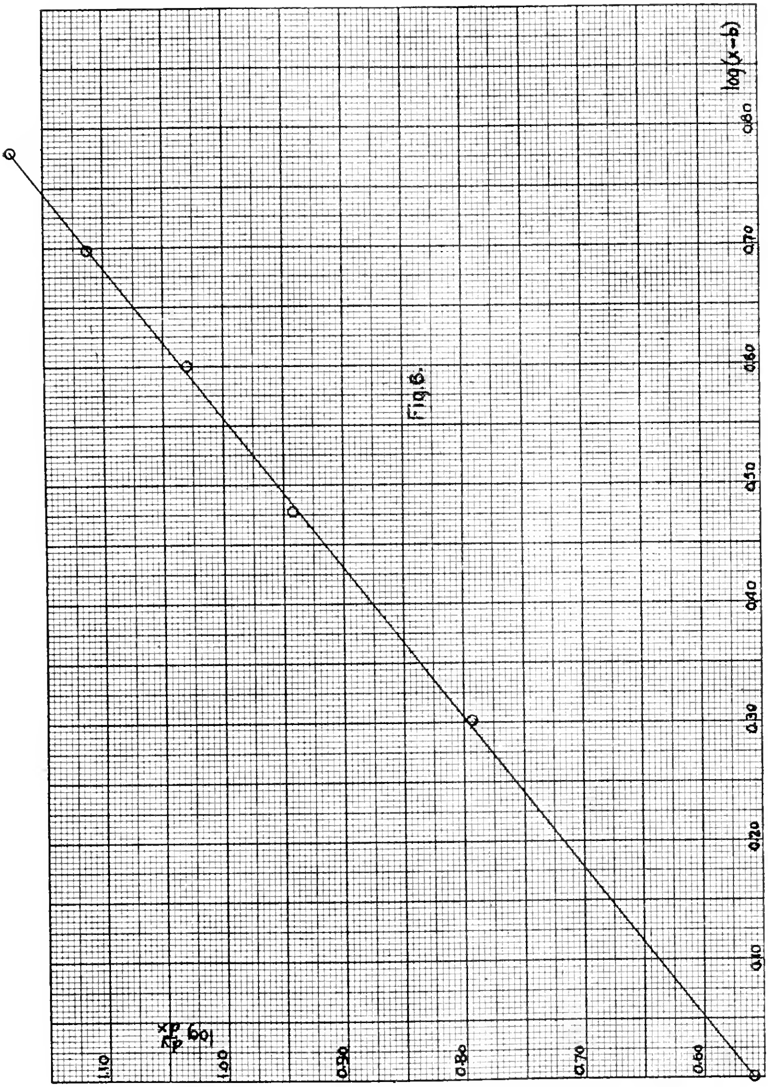


Fig. 6.
log(x−b)
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.60
0.70
0.80
0.90
1.00
1.10

this is similar in form to equation (3), and the method of solution given for that case will then apply.

For example, suppose that curve A of Fig. 5 is to be analyzed, the data from which it is plotted being included in the subjoined table. Construct a number of tangents to the curve, as indicated, and find the numerical value of $\frac{dy}{dx}$ for each point of tangency. Now construct curve B (Fig. 5), whose ordinates are these values of $\frac{dy}{dx}$ and whose abscissas are the points of tangency. Produce curve B until it intersects the axis of X. The abscissa of this point will then be the value of b. Naturally, there will be some uncertainty as to this value, but it may be found with sufficient exactness in two or three trials.

Referring to Fig. 5, b is found to be 1.5, so that in the table we may form the column $(x - b)$. Since

$$\frac{dy}{dx} = kn\,(x - b)^{n-1}$$

it follows that

$$\log \frac{dy}{dx} = \log(kn) + (n - 1)\log(x - b)$$

which is linear in $\log \frac{dy}{dx}$ and $\log(x - b)$. Plotting these quantities as in Fig. 6, we obtain a straight line, from which can be found

$$\log(kn) = 0.557$$
$$n - 1 = 0.796$$

therefore,

$$n = 1.8 \text{ (approximately)}$$
$$k = 2.0$$

Having determined b, k, and n, it is a simple matter to fix the value of a; in this case, $a = 2.3$; so that, finally,

$$y - 2.3 = 2.0\,(x - 1.5)^{1.8}$$

DATA FOR FIGS. 5 AND 6.

x	y	x	$\frac{dy}{dx}$	x — b	$\log \frac{dy}{dx}$	log (x — b)
2.0	2.87	2.5	3.60	1.0	0.556	0.000
3.0	6.45	3.5	6.23	2.0	0.794	0.301
4.0	12.71	4.5	8.78	3.0	0.943	0.477
5.0	21.37	5.5	10.89	4.0	1.037	0.602
6.0	32.27	6.5	13.05	5.0	1.116	0.699
7.0	45.32	7.5	15.10	6.0	1.179	0.778

If an appreciable error is made in selecting the value of b, the line of Fig. 6 will be curved instead of straight; if b is taken too

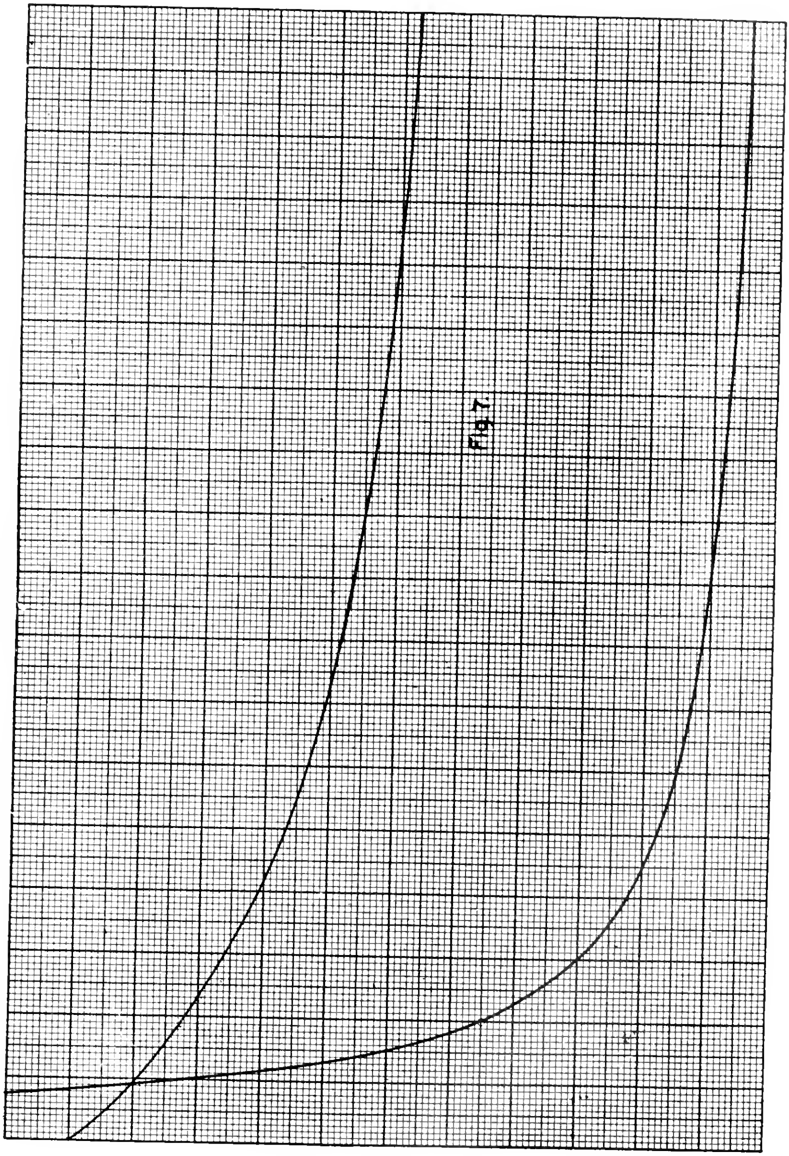


Fig. 7.

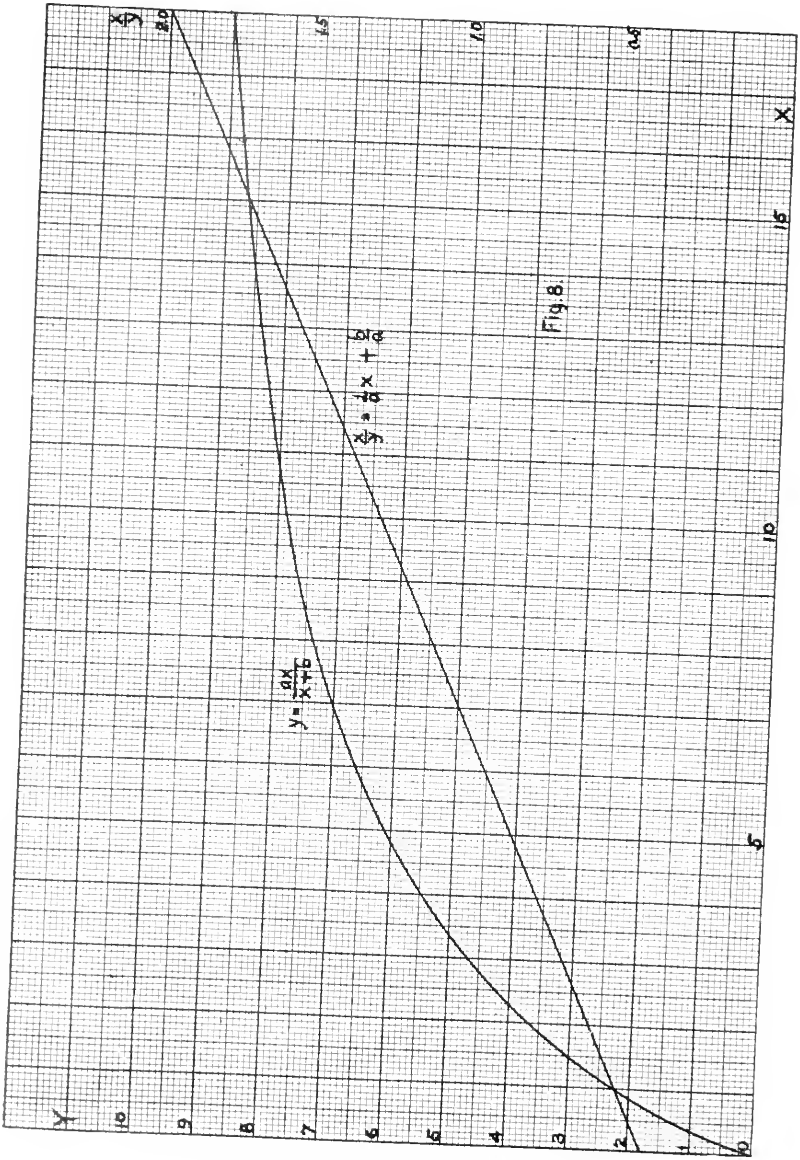


Fig. 8.

large the curvature will be in one direction, and if too small, in the other. Hence, if two such curves are obtained in the course of the work, the true value of b will be between those from which the trial curves resulted, and can be closely approximated by visual interpolation.

The general case here discussed will, of course, fully cover those special cases in which either a or b is absent. If a is zero, the curve will be tangent to the X axis at a distance b from the origin. If b is zero, the origin will be on the axis of Y at a distance a above the origin. It is hardly necessary to add that a and b, in all these equations, may be either positive or negative.

HYPERBOLIC CURVES.

Curves of this class (Fig. 7) may be treated in a manner very similar to that used for parabolic curves. In fact, equation (2) becomes that of a hyperbolic curve if n is negative; in that case the equation may be written

$$(y - a)\ (x - b)^n = k \qquad (7)$$

where n is positive.

Differentiating (7), we have

$$-\frac{dy}{dx} = kn\ (x - b)^{-(n+1)} \qquad (8)$$

or

$$-\frac{1}{\frac{dy}{dx}} = \frac{(x - b)^{n+1}}{kn}$$

If tangents to the curve are drawn at a number of points and corresponding values of x and $\frac{1}{\frac{dy}{dx}}$ are plotted, the curve so determined will cross the axis of X where $x = b$. It is then possible to proceed as in the case of parabolic curves, noting that equation (8) may be written

$$\log\ (-\frac{dy}{dx}) = \log\ (kn) - (n + 1) \log\ (x - b) \qquad (9)$$

There is no anachronism in the expression $\log\left(-\frac{dy}{dx}\right)$, since for all positive values of $(x - b)$, $\frac{dy}{dx}$ will be negative for that branch of the curve lying in the first quadrant.

Hyperbolas are sometimes encountered which have such a position with respect to the axes that they may be readily mistaken for parabolas. Fig. 8 illustrates this class, the general equation of which is

$$y = \frac{ax}{x + b} \qquad (10)$$

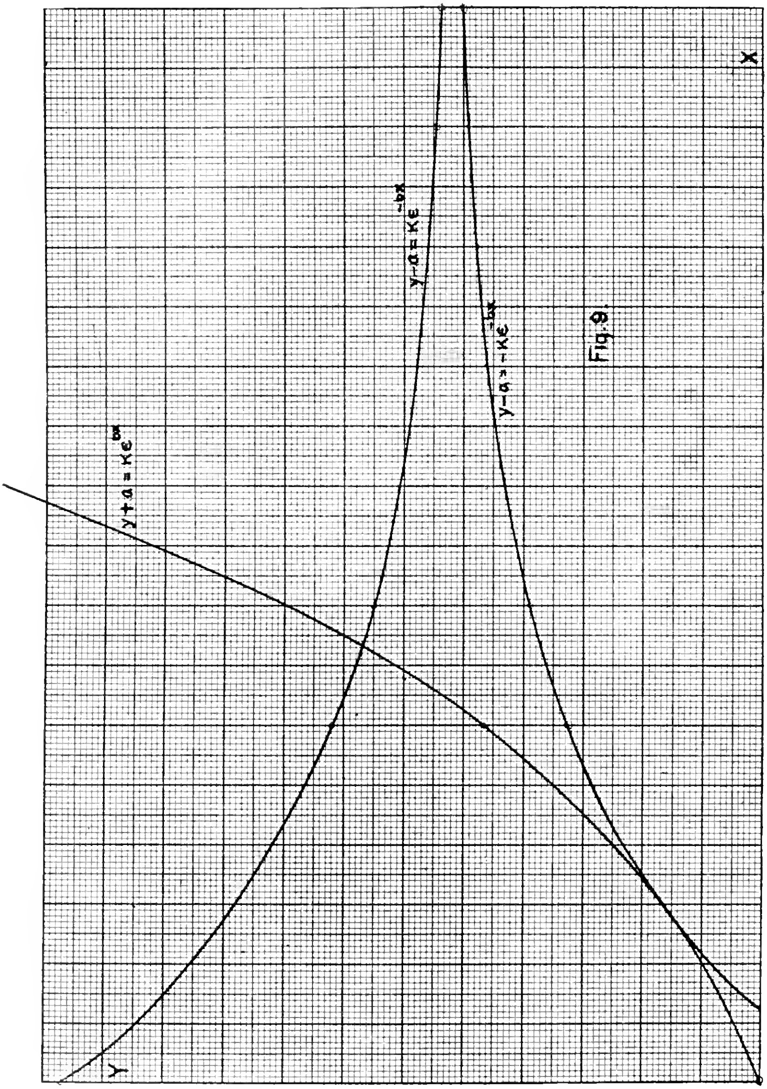


Fig. 9.

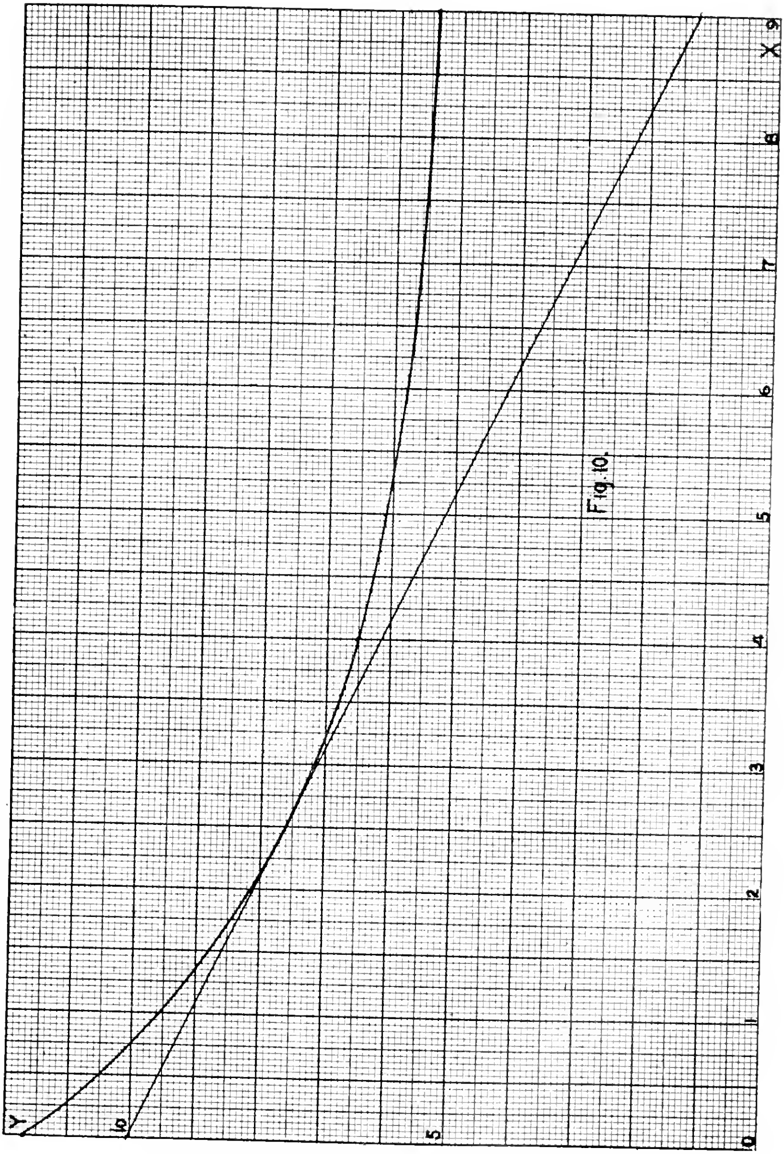


Fig. 10.

If this curve is mistaken for a parabolic one, and the method of analysis involving equations (3) and (4) is employed, the graph of (4) will not be a straight line, thus showing the falsity of the assumption. Close inspection of the actual curve will usually determine which of the two equations (3) or (10) is the better for a first trial, since the graph of the former is tangent to one of the axes, while that of the latter is not.

Equation (10) may be written

$$\frac{x}{y} = \frac{1}{a} x + \frac{b}{a}$$

which is linear in $\frac{x}{y}$ and x; if, therefore, (10) is the true equation of the curve, a straight line should result on plotting $\frac{x}{y}$ and x; and from this line $\frac{1}{a}$ and $\frac{b}{a}$, and thence a and b, may be found. It may be remarked in passing that $x = -b$ and $y = a$ are asymptotes of the curve.

The B-H curve of magnetization and the saturation characteristics of a generator may be conveniently represented by (10), which is identical in form with Frölich's equation.

LOGARITHMIC CURVES.

The general equation of this type is

$$y - a = k\varepsilon^{bx} \qquad (11)$$

where ε is the base of the Naperian system of logarithms, and a, b, and k are constants which may have any values. The variables x and y may be interchanged in (11), in which case the resulting curve and that represented by (11) will be symmetrical with respect to the line $y = x$. In Fig. 9 are shown several typical curves obtained by giving various positive and negative values to the constants.

Differentiating (11), we have

$$\frac{dy}{dx} = kb\varepsilon^{bx} \qquad (12)$$

from which

$$\log_\varepsilon\left(\frac{dy}{dx}\right) = \log_\varepsilon (kb) + bx \qquad (13)$$

Equation (13) is linear in $\log_\varepsilon\left(\frac{dy}{dx}\right)$ and x, so that if a straight line results from plotting these functions it follows that (11) correctly represents the original curve. In addition, the values of b and k follow at once from this straight line according to methods already illustrated. Knowing b and k it is a simple matter to determine a from the original data and curve.

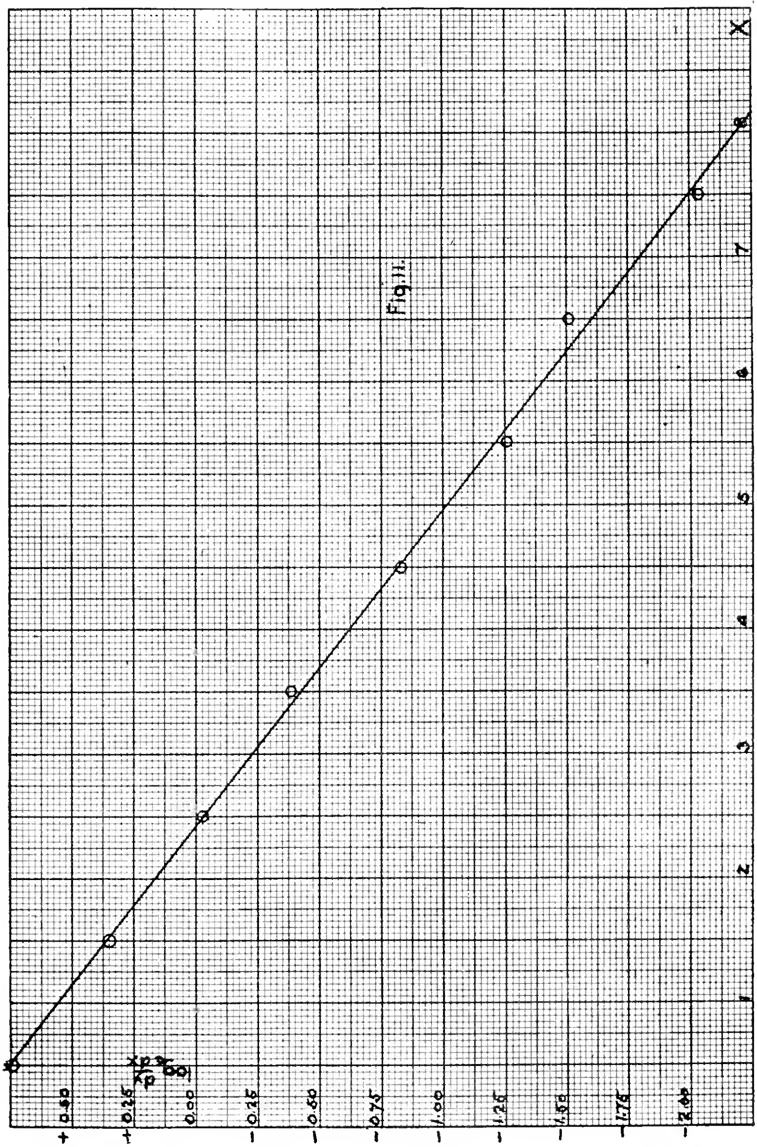


Fig. 11.
X
1
2
3
4
5
6
7
8
+0.50
+0.25
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
-1.75
-2.00

For example, suppose that the curve of Fig. 10 is to be analyzed, and that the original data is contained in the following table. Construct a number of tangents, as indicated, and find the value of $\frac{dy}{dx}$ for each. In the present case, all these values are negative, which indicates at once that b must be negative. But it follows from (12) and (13) that if we take the absolute values of $\frac{dy}{dx}$ and treat them as positive, b will necessarily come out as a negative quantity.

Plotting $\log_\varepsilon\left(-\frac{dy}{dx}\right)$ and x, as in Fig. 11, a straight line is obtained, from which is calculated

$$b = -0.394$$
$$\log_\varepsilon bk = 0.951$$
$$bk = 2.59$$
$$k = 6.57$$

It should be noted that in dividing bk by b their absolute values must be used.

We thus obtain

$$y - a = 6.57\varepsilon^{-0.394x}$$

and, upon inserting a number of corresponding values of x and y from the original curve, the average value of a is found to be 5.2; therefore,

$$y - 5.2 = 6.57\varepsilon^{-0.4x} \text{ (nearly)}$$

is the final expression.

Data for Figs. 10 and 11.

x	y	x	$-\frac{dy}{dx}$	$\log_\varepsilon\left(-\frac{dy}{dx}\right)$
0	11.70	0.5	2.100	+ 0.742
1	9.56	1.5	1.420	+ 0.351
2	8.12	2.5	0.975	— 0.025
3	7.16	3.5	0.663	— 0.411
4	6.51	4.5	0.436	— 0.830
5	6.08	5.5	0.286	— 1.252
6	5.79	6.5	0.221	— 1.505
7	5.60	7.5	0.130	— 2.040
8	5.47			
9	5.38			

SUMMARY.

In the methods described in the foregoing sections, the form of the tentative equation is modified by any legitimate process in such a manner that the variables in the original equation become

collected into two groups, or terms, all other terms involving constants only. On calculating the values of these group terms from the original data, and plotting them as new variables, a straight line should result if the assumed form of equation is correct. The chief advantage of this method lies in the fact that the values of the constants thus determined have far greater accuracy than could be otherwise obtained. It will also be observed that for all the curves treated as in the above sections, the principal functions to be handled are, besides x and y themselves, $\frac{dy}{dx}$, $\log \frac{dy}{dx}$ and $\log x$ (or $\log (x - b)$). When these functions have been calculated, they may be used quickly for trying the various possible combinations.

The methods thus described apply, of course, only to the limited number of cases explained; but they may be readily extended in a manner that will be at once evident to anyone familiar with the equations of other families of curves.

THE UTILIZATION OF NIAGARA POWER.

By H. W. Buck, Electrical Engineer, Niagara Falls Power Company.

[Read before the Engineers' Society of Western New York, April 5, 1904.*]

The utilization of the power of Niagara Falls has for years been the dream of engineers and of all those interested in the industrial development of this section of the country. In the past, many schemes for the purpose have been suggested by inventors and others, but never, until the advent of the modern era in electrical engineering, has the proposition, on a large scale, been able to stand upon a basis attractive to the capitalist. It may therefore almost be claimed that the problem of utilizing the power of Niagara has been solved technically by the profession of electrical engineering.

The difficulty in the past has not been to apply the water to the turning of a water wheel, for many of the schemes suggested would have accomplished this successfully, but what to do with the power when developed at the water-wheel shaft was the problem before the engineer. Obviously, here the question of transmission arose as of prime importance.

Among the numerous early plans will be found extensive systems of pneumatic tubes operated by turbine-driven air compressors, the pipes leading to factories located in the vicinity of a power house. Each factory was to have its own air motor thus operated. It may be of interest to note that one of these plans contemplated the transmission of power to Buffalo by this means.

Another plan consisted in lines of countershafting bracketed on columns extending radially from a central power station, this long shafting to be driven by the water wheels through a system of gearing. Factories were to be located along these lines of shafting and were to receive their power supply by clutches connected to these shafts.

Still another plan involved the construction of a network of surface canals fed from a common intake from the Niagara River. Factories were to locate along these canals and take water from them for the operation of individual turbines; the water to be discharged into branch tunnels connected to a main trunk tunnel leading to the lower river.

These plans now look grotesque, but at that time, 20 years ago or so, they were seriously considered by good engineers. They

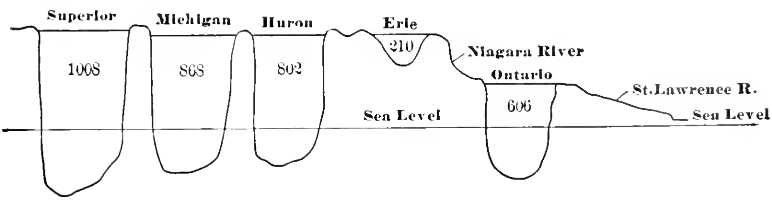
* Manuscript received May 6, 1904.—Secretary, Ass'n of Eng. Socs.

were discarded largely for financial reasons, the plans showing low efficiency and high cost of construction and maintenance.

We are all familiar with the final solution of the problem, and the power house of the Niagara Falls Power Co. need not be described in detail. The electrical solution seems almost ideal as a means of distributing the power. A dynamo has no links, gears or valves to wear out. It revolves day in and day out, with almost no attention, and its efficiency is so high that 98 per cent. of the energy of the turbine shaft is delivered at the terminals of the dynamo. From the electric generator the current is carried over wires and cables which afford almost the limit of simplicity as a means of transmitting power to the user.

Many who come for the first time to the Niagara power house are surprised to find the plant located so far from the Falls. They have always associated the use of Niagara's power with the Falls themselves, and it is difficult for them to understand that the power is derived from the difference in level between the upper and the lower river, of which the Falls are merely a result.

The person who originated the conundrum about not being able to "dam" Niagara knew very little about hydraulic conditions there. The Falls are the direct result of an enormous dam which extends from Buffalo to the brink of the Falls for its thickness, and for its length it has the length of the entire Niagara escarpment itself, the spillway being the Niagara River. If it were not for this dam the waters of Lake Erie would be discharged abruptly into Lake Ontario.



PROFILE OF THE GREAT LAKES, SHOWING THEIR DEPTHS IN FEET.

The ultimate hydraulic conditions at Niagara, therefore, are not so different from those of other water-power plants, except in the matter of size and from the fact that the dam has been built by nature and not by man.

From the electrical distribution of Niagara power has resulted a radical and essential advantage which was not fully recognized at the time of its first adoption. As its uses have developed, it has been found that not only was *power* wanted for industrial purposes, but primarily *electric* power. This is especially true in

the case of the electro-chemical and electric lighting applications. If pneumatic, hydraulic or mechanical shaft power had been supplied for use it would have been necessary for all the electro-chemical plants to convert this power into electric current before they could use it, with all the loss in power which would result from this conversion. So also with the electric lighting and electric railway applications, where power is wanted in the form of electric current.

The first power house of the Niagara Falls Power Co. has a capacity of 50,000 horse power, made up of 10 generating units of 5000 horse power each. The second plant of this same company, which is located on the opposite side of the inlet canal, has just been completed, and its capacity is 55,000 horse power from 11 generators of 5000 horse power each.

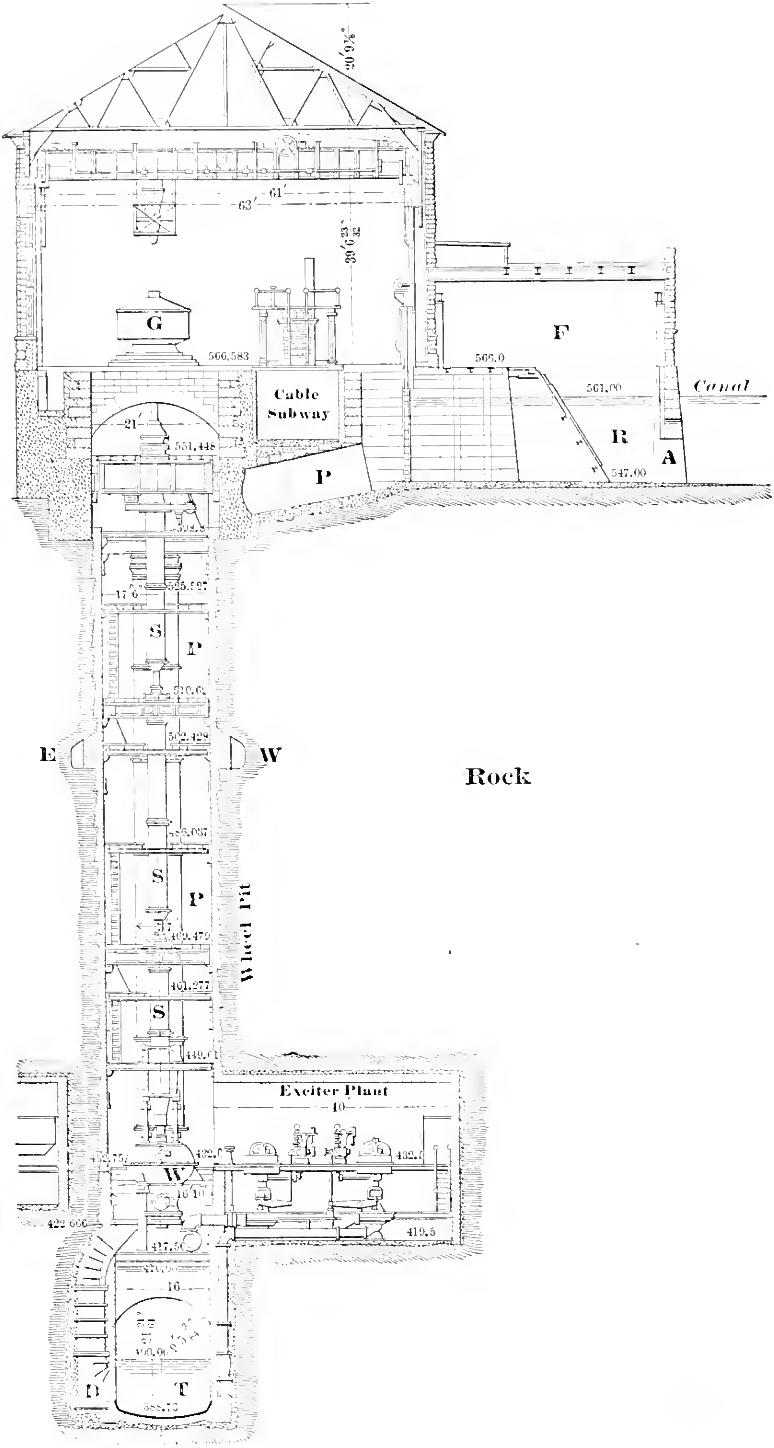
The general features of this plant are the same as those of the older power house, the difference being in a few details. The turbines are operated with draft tubes which increase the effective head of water and consequently the power for a given amount of water. The water is drawn from the old canal, led through penstocks to the turbines and discharged through them into a branch tunnel. This connects with the main tunnel at a point near the end of wheel pit No. 1.

The cut opposite shows power house No. 2 in section, and illustrates one unit and the general method adopted by the Niagara Falls Power Co. of using the hydraulic energy at Niagara. From the canal which connects with the upper river the water flows through submerged arches A as shown and into the inclosed forebay F, thence through the racks R into the penstocks P and down the wheelpit to the turbines which are inclosed in the wheel case W. From the wheel case the water passes through the buckets of the turbine and down through the draught tubes D into the tailrace T. This connects with the discharge tunnel which carries the water off under the city to the lower river.

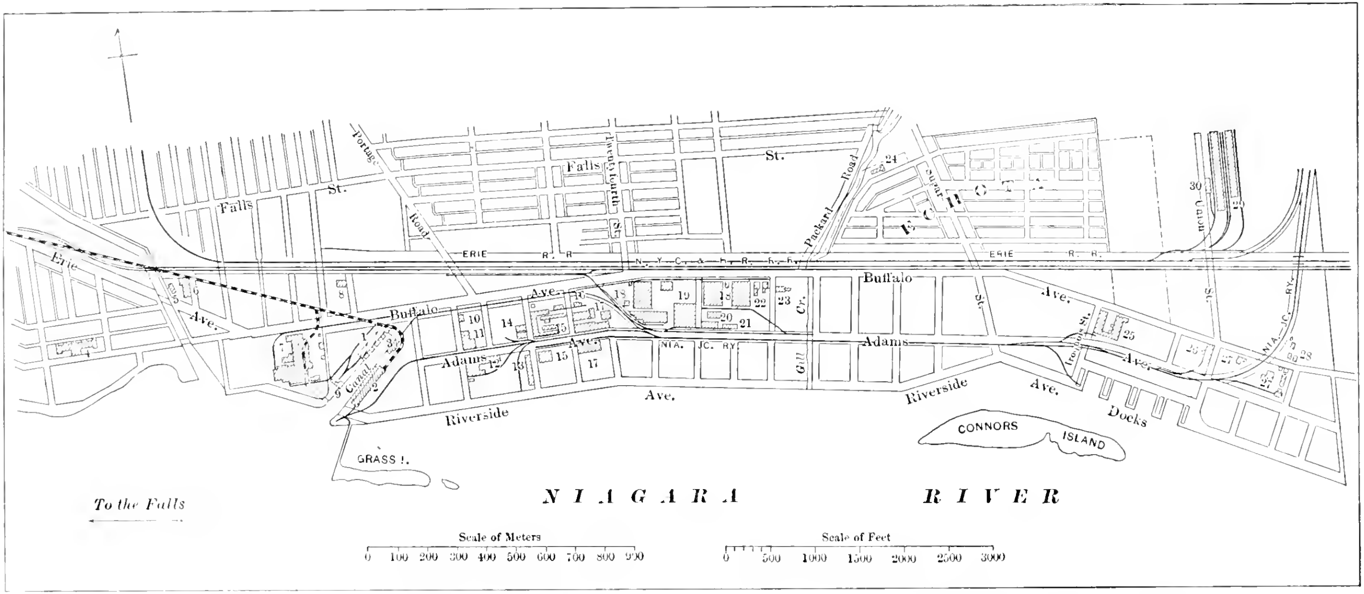
The turbine is direct connected to the electric generator G by means of the vertical hollow shaft S. The speed is 250 revolutions per minute.

Electrically, the arrangements of power house No. 2 differ materially from those of the old plant. There are 2 types of dynamos. The first 6 are very similar to the 10 machines in plant No. 1, but the last 5 are entirely different in construction; in them the field revolves inside of the stationary outside armature.

In the new plant the generators are all wound for the same voltage, phase and frequency as in the old plant machines, so as to permit of interchangeable operation on the system. The

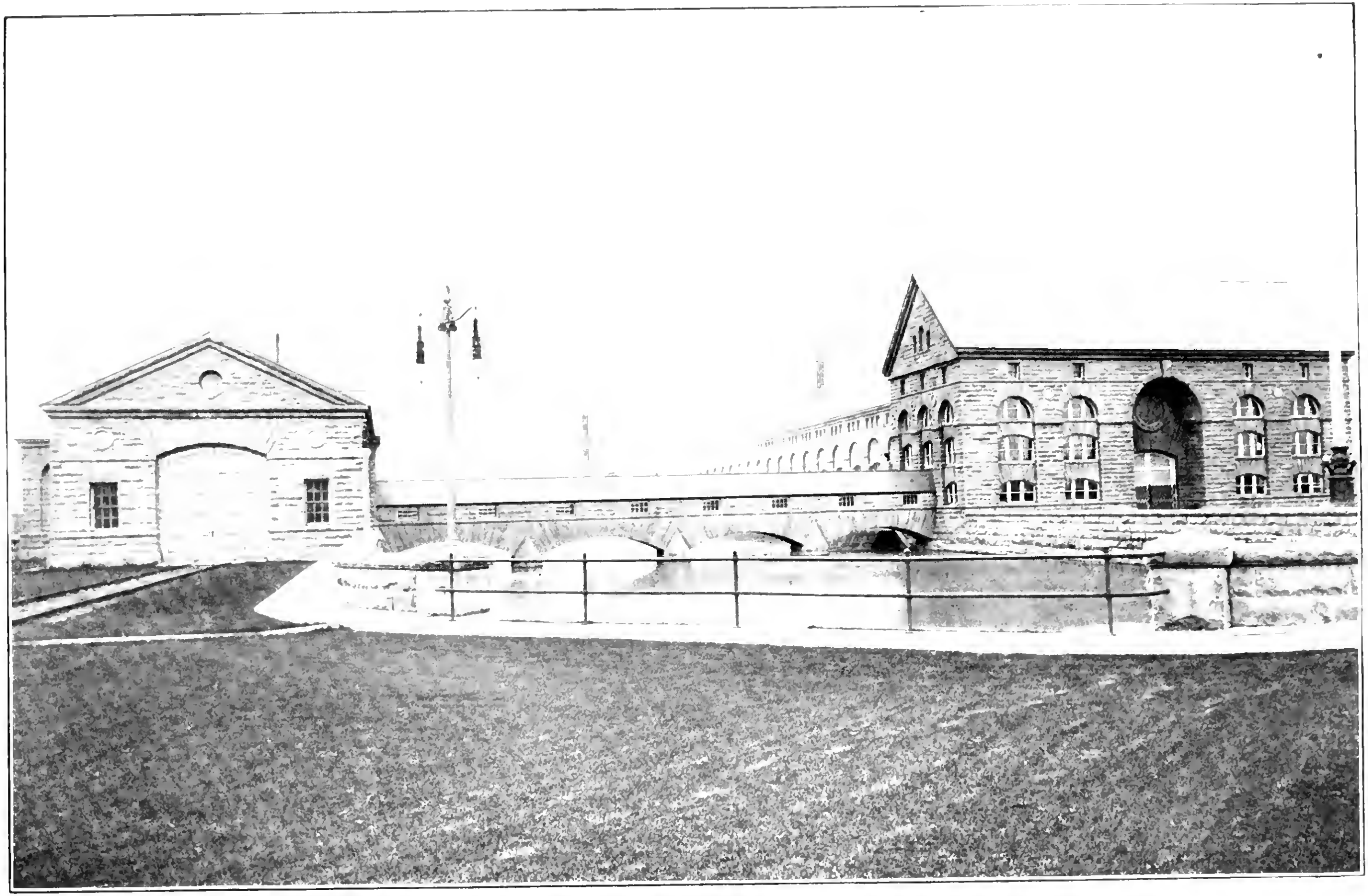


SECTION OF POWER HOUSE No. 2.



THE NIAGARA FALLS POWER CO. GENERAL MAP SHOWING LOCAL DISTRIBUTION OF ELECTRIC POWER.

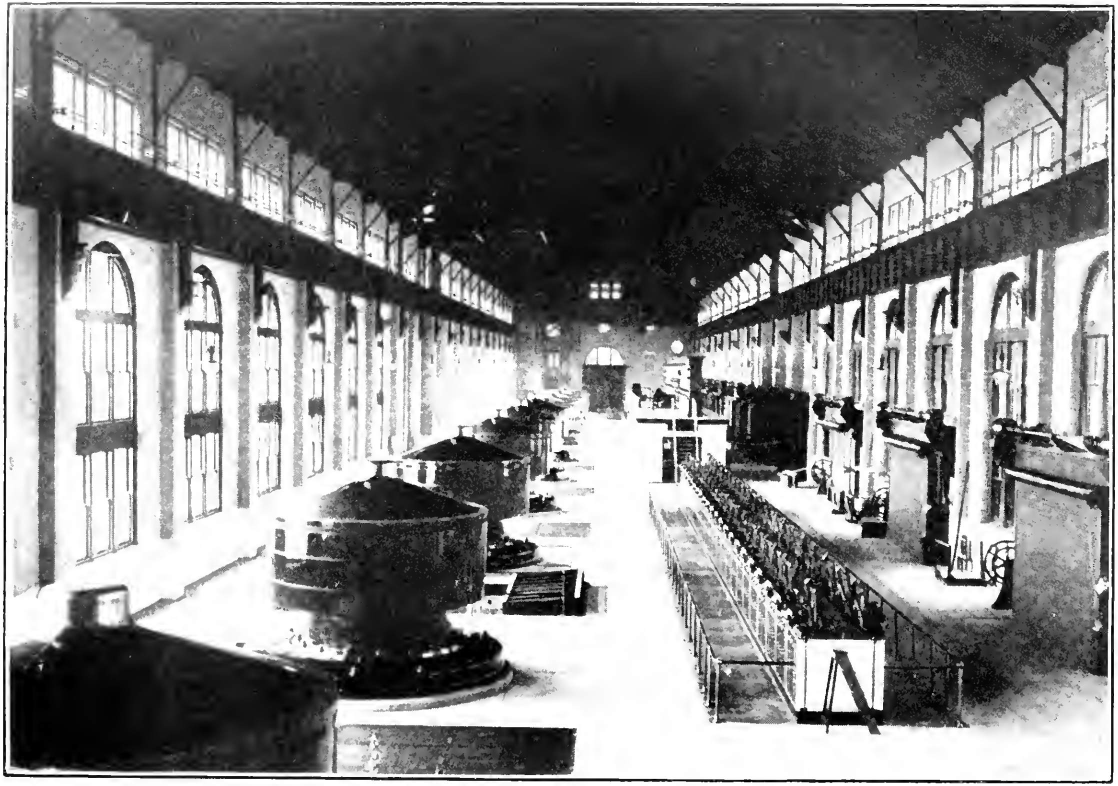
1. Power House No. 1.
2. Power House No. 2.
3. Main Transformer Station.
4. The Natural Food Co.
5. Francis Hook and Eye and Fastener Co.
6. Niagara Surface Coating Co.
7. International Paper Co.
8. Buffalo and Niagara Falls Electric Light and Power Co.
9. The Niagara Falls Waterworks Co.
10. Niagara Research Laboratories.
11. Electrical Lead Reduction Co.
12. By-Products Paper Co.
13. Composite Board Co.
14. International Acheson Graphite Co.
15. The Carborundum Co.
16. Atmospheric Products Co
17. The Pittsburg Reduction Co.
18. Castner Electrolytic Alkali Co.
19. Niagara Electro-Chemical Co.
20. The United Barium Co.
21. Ampere Electro-Chemical Co.
22. Norton Emery Wheel Co.
23. Acetyvone Manufacturing Co.
24. Echota Disposal Works.
25. Ramapo Iron Works.
26. Roberts Chemical Co.
27. Oldbury Electro-Chemical Co.
28. Phosphorus Compounds Co.
29. Union Carbide Co.
30. Union Street Sub-Station.



Power House No. 1 and Transformer House.

Power House No. 1. Interior.

Power House No. 2.



Power House No. 2. Interior.

switchboard arrangements are different and in accordance with the most approved modern methods of construction.

In addition to power house No. 2, the Niagara Falls Power Co. is developing, through its allied company, the Canadian Niagara Power Co., 110,000 horse power on the Canadian side of the Falls. The hydraulic features of this development are very similar to those on the American side, which have proved so successful in operation. A wheel pit has been excavated in Victoria Park at a place about 1700 feet above the Horse Shoe Falls. Into this pit the water is discharged from a short intake canal and forebay, and carried off through a tunnel to the lower river.

The essential difference involved in this plant is in the size of the generating unit. The installation will consist of 11 units of 10,000 horse power each. When the power development was first started on the American side, a unit of 5000 horse power was selected as being a convenient subdivision of the total power development then contemplated, viz: 100,000 horse power. Now that more than 200,000 horse power is to be developed, a 10,000 horse-power unit can be installed and its relation to the capacity of the whole system will remain the same. Furthermore, great economy in cost of construction results in the use of this larger unit. A 10,000 horse-power turbine and dynamo occupy only slightly more space than one of 5000 horse-power capacity. This effects a considerable saving in length of power house, forebay, wheel pit, etc., for a given plant output. Also the cost of one 10,000 horse-power turbine and dynamo is less than the cost of two 5000 horse-power units. The advance in the art of turbine and dynamo manufacture in the last 10 years has been such that the construction of 10,000 horse-power machines now is not as difficult a problem as was that of the 5000 horse-power size when the first American power house was built.

The electric generators in the Canadian plant are wound for 11,000 volts, 3 phase. This voltage, which is 5 times as high as that of the American plant dynamos, was selected for reasons of economy in power distribution. This is about the highest voltage which is considered safe for underground distribution, and all the power will be taken out from the Canadian plant underground, necessarily, on account of the power house being in the Park.

For very long distance transmission, transformation will take place to a much higher voltage in a transformer station located on the plateau above the Park. Transformation will be made to 22,000, 40,000 or 60,000 volts, depending upon the transmission distance.

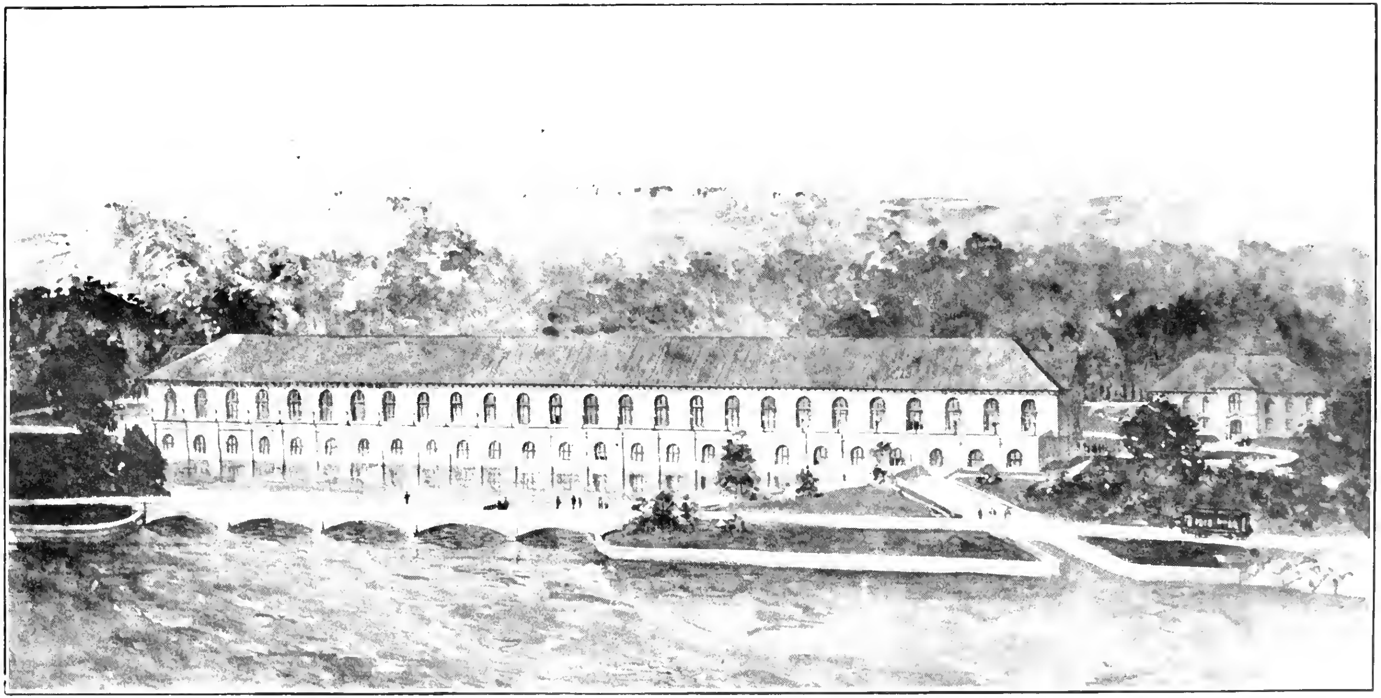
The Canadian plant will be electrically interconnected with both of the American power houses by cables across the upper steel arch bridge, so that 3 large independent generating stations will be available for the supply of power to the system of the Niagara Falls Power Co. This is a matter of the greatest importance to the Niagara frontier. In case of some unforeseen accident to any one of the plants, interconnections could at once be established so that the most important users of power, supplied normally by the disabled plant, could be supplied with power without interruption. This is especially important where the public utilities are involved, such as the electric railways and electric lighting companies.

One naturally asks where this 215,000 horse power is going to be used. The same question was asked in regard to the 50,000 horse power for which the first power house was constructed. The latter has been quickly answered by the fact that the load this winter exceeded 75,000 horse power. At the present rate of increase it will not be many years before the capacity of all 3 plants is reached.

The use of machine tools and mechanical processes in factories nowadays consumes a large amount of power, and the cost of power has therefore become a very important item to the manufacturer. It has made him investigate carefully the question of power cost, and the saving in this account which results from the use of power from the Niagara system as compared with that from an isolated plant. The central locality in the country of the Niagara frontier is also attracting attention in the industrial world, and I should not be surprised to see, during the next 10 years, a great influx of all classes of manufacturing concerns, attracted to this locality by the advantages named. Electro-chemistry is only just beginning to open up as an enormous user of electric power, and it is likely that many processes will be invented which will require the cheap power of Niagara to render them commercially operative.

All such industrial development means more homes and more people, which in turn require more electric lighting and more street railway traffic, which again increase the use of power. An enormous field for the use of Niagara power, which is only just beginning to open up, is the electric operation of the passenger and freight traffic on the great steam railroad trunk lines. In my opinion this is sure to come in the near future.

If you will draw a circle around Niagara Falls as a center, with a radius equal to about 100 miles, which might be considered as a fair limit of economical transmission under present electrical



Power House of Canadian Niagara Power Co.

conditions, and assume all the trains in this circle to be operated by Niagara power at approximately 500 to 1000 horse power per train, you will see the possibilities in this direction for the consumption of power from the Falls.

In spite of the possibilities for long distance transmission use, I believe, nevertheless, that the bulk of Niagara power will always be used within a radius of a few miles of the Falls. It is cheap power that the manufacturers want, especially those of electrochemical products, and the nearer they get to the Falls the cheaper will be the power.

Transmission of power for long distances is expensive at best. Take the case, for instance, of the Niagara-Buffalo transmission. The current, after it leaves the generators, is transformed to 22,000 volts by expensive step-up transformers, which not only waste some of the power, but must be operated and maintained, and interest must be paid upon their cost. From here the current traverses the transmission line over a private right of way. This also must be operated and maintained, and interest must be paid upon a large investment in line as well as for right of way. Furthermore, power is lost in the transmission. After reaching the city line of Buffalo, the current is again transformed for distribution throughout the city. This distribution is accomplished by means of an extensive system of underground cables. All this apparatus must have fixed interest charges paid upon it and it requires a large force of experienced men for its operation. When, therefore, the statement is made that not over 10 per cent. is lost in transmitting power from Niagara to Buffalo, it does not mean that power will cost only 10 per cent. more in Buffalo than at the Falls; for the difference will be much greater than this.

However, even with this transmission cost added, Niagara power is delivered in Buffalo to-day to customers more cheaply than they can produce it themselves by isolated plants. The saving in cost is not the only advantage. The elimination of the steam boiler and engine outfit in a factory by the use of Niagara power is a luxury and a convenience which has many incidental commercial advantages.

When the Niagara enterprise was first started there was a great deal of talk about operating all the factories in New York State by Niagara power. Such a possibility, under the present state of electrical science, is theoretical only; for electric power, transmitted to such distances by present methods, could not possibly compete with steam. In theory, Niagara power can be sent to

San Francisco in any amount, but its cost, when it got there, would be prohibitive.

Another argument against transmitting Niagara power to a long distance from the Falls, is that it is not commercially necessary to do so. There will be probably a sufficient market for power within a 50-mile radius of the power house to use up all the power which has thus far been developed, and it is likely to continue so. It is cheaper for the factories to locate near the Falls than to carry the power a long way to the factories.

One exception to this general tendency against the transmission of Niagara power to long distances is in the case of the steam railroads mentioned above. If they change over to the use of electric power, it is likely that they will use Niagara power within a circle of wide radius about the Falls, possibly 100 to 150 miles. In their case the conditions are peculiarly favorable for long distance transmission. They will use power on a large scale, and will have their own private rights of way, without extra cost for the installation of their overhead circuits. Furthermore, they will have to compete electrically only with steam power as developed in the locomotive, which, as is well known, is a very expensive method of utilizing the energy of coal, as compared with a stationary engine.

At present the power distributed by the Niagara Falls Power Co. might be divided into 3 classes.

First. The local service to electro-chemical and other industries within the city limits of Niagara Falls. This at present aggregates about 45,000 horse power, divided among 30 industries. The largest users are the electro-chemical plants, which require current either for electrolysis or for the production of the very high temperatures obtainable in the electric furnace by which the reactions in their processes are brought about.

Second. The Canadian service across the upper steel arch bridge to industries and electric railroads in Canada, reaching as far as St. Catharines. This use is small at present, but it is the beginning of an industrial growth on the Canadian side of the river, which, in my opinion, will be very extensive in a few years. It now amounts to about 2000 horse power.

Third. Long distance service to Buffalo, Tonawanda, Lockport and Olcott, which now amounts to a total of about 30,000 horse power. In Buffalo approximately 24,000 horse power is used, divided among a very large number of customers, making use of the power for all kinds of purposes. This includes the power for operating the Buffalo street cars and the electric lights in the city.

In Tonawanda about 4000 horse power is used for railway, lighting and miscellaneous power purposes.

In Lockport the use amounts to about 1500 horse power for railway and miscellaneous purposes. Five hundred horse power is used at Olcott for operating one of the substations of the International Railway Co. This station is 39 miles from the Falls, which is at present the longest distance to which Niagara power is transmitted. All the freight on the International Railroad, between Olcott and Tonawanda, is handled by Niagara power by means of electric locomotives.

It is hoped that this brief outline will give an idea of the present status of the Niagara Falls Power Co. system. It represents, however, merely the beginning. In this country great cities have sprung up in certain localities for reasons far less important commercially than the conditions which exist on the Niagara frontier to-day. It is the center of population of the continent, approximately a focus of all the great trunk line railroads, and unlimited cheap power for manufacturing is available. It is also the eastern terminus of the Great Lakes' commerce. This latter, if the Niagara River is deepened, will be extended almost to the brink of the Falls themselves, affording 20 miles of sheltered dock front.

The day will come when we shall see a steamless city, reaching unbroken from Buffalo to the Falls, the industrial triumph of Niagara's power.

PROGRESS IN RAILROAD BRIDGE BUILDING.

By F. C. McMath, President of the Detroit Engineering Society.

[Address delivered at the Tenth Annual Banquet of the Society, April 29, 1904.*]

It is probably safe to say that nowhere in the world has the art of bridge building progressed faster than in the United States. Previous to 1860 practically all of our truss bridges were of timber construction—mainly of the Howe truss type. About this date the building of spans with cast-iron compression members and wrought-iron tension members became the fashion, and a few metal bridge building establishments sprang up; each concern usually adhering to some particular type of construction, such as the Fink truss or Bollman truss. It may interest the members of the Society to know that the old Detroit Bridge and Iron Works was one of these pioneer companies and built bridges under the Bollman patents. Metal bridges were something of a luxury in those days, the old records of the Detroit Bridge and Iron Works showing prices from 8 to 10 cents per pound. Not many railroads could afford metal structures at such figures, and combination wood and iron bridges began to be largely used, especially by the railroads in the West.

About 1880, bridges constructed entirely of wrought iron began to be commonly used. Seven or eight years later, steel eyebars were substituted for wrought-iron tension members, and about 1890 the iron compression members had to give way to those of steel.

The change from iron to steel was opposed by many engineers, but steel won the day on account of its lower cost.

During the period of change in the materials of bridge building, a very great change took place in the weight of rolling stock. In 1860 an ordinary locomotive and tender would weight about 40 tons; in 1880 a 66-ton engine was thought a monster. In 1890 engines of 100 tons were believed to be about the limit, but now there are plenty of engines weighing, with tender, 140 to 150 tons. These radical increases in loads naturally have had a marked effect on the bridge building industry. A bridge built for the loads of 1860 needed renewal about 1880, and structures designed for 1880 conditions had to come out before 1900. This is an understatement rather than an exaggeration. I know of one structure in Michigan that has been renewed no less than three times by one company. It is doubtful whether the limit in loads has yet been reached, but

* Manuscript received June 1, 1904.—Secretary, Ass'n of Eng. Socs.

this is a matter for the railroad engineers to worry about; not for the bridge builder to lose sleep over.

Pin-connected spans have been the favorite type in the United States from the earliest days of metal bridge building. Some years ago quite a controversy arose between American and English engineers as to the relative merits of pin and riveted spans, the latter being the distinctly English type. American engineers apparently had the best of the argument, the pin structures being unquestionably lighter in weight and cheaper to erect. In recent years, however, a strong tendency has set in toward the use of riveted structures for spans of short or moderate length. Most bridge engineers would not now use pin designs for spans less than 125 feet; and a few railroads, such as the New York Central Railroad, have practically cut out pin bridges altogether and are now making the riveted bridge their standard type. In Canada the riveted bridge has been in favor for some time by the leading railroad companies, being used quite generally for all spans up to 200 feet, whether single or double track.

There can now be no question that the English engineers were pretty much in the right in their old contention in favor of riveted bridges—at least for spans less than 200 feet, which cover the bulk of ordinary railroad structures. American engineers, however, have by no means copied English designs, even if they are coming around to the English type.

American designs use longer panels and much deeper trusses, and on this account our structures are lighter, stiffer, better and cheaper than the English. For some occult reason the English engineer feels that the slope of his diagonal truss members must be exactly 45°, if possible, and that the depth of truss must not exceed $\frac{1}{8}$ the span length. His adherence to these thumb rules makes his designs heavy and expensive, and, for short spans, often defective in their top chord bracing. They use difficult details, apparently taken from their shipbuilding practice, where probably there are good reasons for their use, for it must be admitted that they are masters of the art of shipbuilding.

During the past few years a marked improvement has been made in bridge floors. Timber floors are still in general use, but cross ties and guards are now much more substantial than formerly, and the space between the ties has been reduced from 8 inches or more down to 4 inches. Some of the trunk lines are abandoning timber floors altogether, and are using solid metal floors carrying gravel or rock ballast. These floors are exceedingly satisfactory in actual use, their great weight and rigidity reducing impact and

vibration to a minimum. The only objection to such floors lies in their higher first cost and liability to deterioration by rust. The most common type of solid floor is the trough floor, but it is expensive and very difficult to protect against rust. It may interest the Society to know that the cheapest and best type of solid floor is one designed by a member of this Society. It is in general use on the Michigan Central Railroad, and is being used to an increasing extent by other roads. A proper name for this type would be "the Douglas Solid Floor."

In the last two decades great progress has been made by the manufacturers of bridges. General methods and processes have shown no radical changes; but better system, more powerful machinery, pneumatic and electric handling devices, have reduced costs. Bridge shops have greatly increased in number and in capacity. Fifteen years ago no single concern had a capacity exceeding 2000 tons of bridge work per month. This output at the present time is far exceeded by many shops, and there is now a single plant with an estimated monthly capacity of 20,000 tons. This is the new plant recently completed by the American Bridge Company, at Ambridge, near Pittsburg. Some idea of the scale of the concern will be gained when it is known that provision has been made in the office for upward of 500 draughtsmen. Single pieces weighing 80 tons can be made and handled in this shop. Eyebars 16 inches wide can be made in the forge department.

Structures can be built to-day that would have been impossible a few years ago. This is the day of big things in bridge building, as well as in other lines of work. More huge bridges are under way than ever before. A 671-foot cantilever span is being built over the Mississippi River, at Thebes, Ill. The Wabash Railroad is about completing 2 huge cantilevers—one of 700 feet span over the Ohio, and one of 812 feet over the Monongahela River. At Quebec a cantilever span is being built over the St. Lawrence River, with a record-breaking span of 1800 feet. At New York a 1600-foot wire cable suspension bridge over the East River has been completed, and contracts have been let for a second bridge of cantilever construction, with a span of 1182 feet. Plans are under way for a third bridge of 1470 feet span, suspension type with eyebar cables.

In these last two structures, nickel-steel eyebars are to be used for the first time. The specifications for these bridges require full-sized annealed nickel-steel eyebars to have an ultimate tensile strength of not less than 85,000 pounds per square inch, whereas the minimum permitted for ordinary steel eyebars is only 56,000

pounds. It is thus apparent that the nickel-steel is about 50 per cent. stronger than the ordinary steel, a gain of enormous importance in bridge building. If nickel-steel can be supplied at reasonable figures, it will be widely used, especially in long spans.

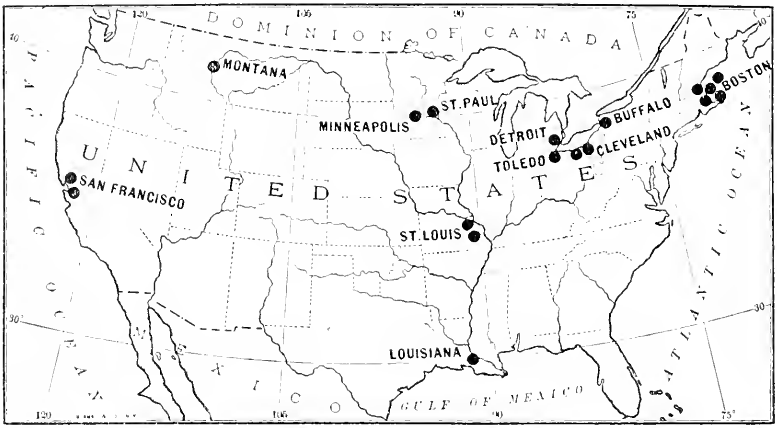
The former head of the United States Steel Corporation, Mr. Schwab, is evidently a believer in the future of nickel-steel, as he has cornered the supply of nickel. His concern, The Orford Copper Co., is now arranging for the rolling of a quantity of nickel-steel plates and angles with a view to having bridge shops try them under the ordinary processes of construction. If no unforeseen difficulties are encountered, it should be feasible to use, in long spans, nickel-steel for compression members as well as for eyebars.

Progress in bridge building has certainly been of great magnitude in the past, but there is still plenty of opportunity for further development and improvement. Some of the advocates of concrete-steel are prophesying the substitution of concrete-steel in place of steel girders for short railroad bridges, but the metal bridge builders are not yet particularly worried over prospective loss of this business.

There is yet much to be done in the way of standardizing bridge specifications. Various opinions are still held by engineers regarding the quality of steel to be used, loads to be provided for, and permissible unit strains.

Prof. Heller, of the Ohio State University, has recently made an interesting comparison of railway bridge specifications. He made a detailed comparison of about 30 railroad specifications, and found a surprising lack of uniformity. Selecting a certain member of the bottom chord of a 134-foot span, he found, under a given loading, the total stress to be 270,000 pounds. Using the averages of unit stresses of 28 different specifications, he found 25.4 square inches of metal required to resist this strain. The area required by the lightest specification was 11.4 per cent. below the average, whereas the heaviest specification required 18.6 per cent. more area, the total variation thus amounting to 30 per cent. He made similar calculations for the stringers of the same span, and found a total variation of 55 per cent. from the average.

Bridge designing is supposed to be one of the exact sciences, but it is very evident that there is no reason for bridge engineers to brag of exactness when their opinions of unit stresses vary to the extent shown above. It is to be hoped that, at some not very distant day, they will get together and adopt a standard specification. Strong efforts are now being made in this direction, and it is the devout wish of the bridge builder that they may be successful.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

Association of Engineering Societies.

Vol. XXXII. JANUARY, 1904. No. 1.

PROCEEDINGS.

Engineers' Society of Western New York.

Annual Meeting, Buffalo, N. Y., December 21, 1903.—The meeting was held in the rooms of the Society, 533 Ellicott Square, on Tuesday, December 1, 1903, Vice-President Norton in the chair.

Mr. Geo. B. Bassett was appointed to examine the reports of the Secretary and the Treasurer.

The reports of the officers were received. The meeting then proceeded to count the ballots for officers. The Vice-President declared that the following persons were elected:

President—Chas. E. P. Babcock.
Vice-President—Thomas W. Wilson.
Director (for one year)—Samuel J. Dark.
Director (for three years)—Louis H. Knapp.
Secretary—Harry B. Alverson.
Treasurer—Frank N. Speyer.
Librarian—William A. Haven.

The meeting then adjourned to meet at 8 o'clock in the evening, at the University Club. At the adjourned meeting about fifteen members were present, and during the evening they discussed the state of the Society and suggested various plans for its improvement, and adjourned at midnight.

(Signed) Lee W. Eighmy, *Secretary.*

Annual Report of the Secretary, 1903.

To the President and Members of the Engineers' Society of Western New York:

I submit the following annual report for 1903:

Total Membership, December 1, 1902	84
Total membership, December —, 1903	83
Consisting of:	
Honorary member	1
Members	65
Associates	13
Juniors	4

MONEYS.

Amounts received December 1, 1902, to December 1, 1903:

For entrance fees	$40.00
For dues	493.75
For key deposits	.75
For JOURNAL advertisements	50.00
For annual dinner fees	2.00
For extra printed copies of paper on "Metric System"	5.00
Total	$591.50

Amount deposited with the Treasurer, 1903..........$591.50

The Society has held eight meetings during the last year, at which the following papers were presented:

January.—"Abatement of the Smoke Nuisance in the City of Buffalo"—report of special committee—read by Mr. Louis H. Knapp.

February.—"Hydraulic Questions of the Proposed Buffalo River Improvement," by Mr. Geo. H. Norton.

March.—"Track Construction of the International Railway Company in Buffalo," by Mr. Thos. W. Wilson.

April.—"Good Roads," by Mr. George C. Diehl.

May.—"Value of Inspection," by Mr. Walter H. Golden.

June.—"Telephony," by Mr. Wilbur H. Johnson.

October.—"Observations on the Littoral, Easterly End of Lake Erie and Head of Niagara River," by Dr. Geo. E. Fell.

There was no quorum at the September meeting and no literary program for the November meeting, which was held on the night of "Election," and it has been suggested that the November meeting date be changed on this account.

A paper was read before the Society at every meeting except this one. The average attendance has been twelve. That was also the average attendance for 1902, during which four papers were presented. Mr. Roberts, the Secretary for that year, suggested, in his annual report, that if more papers could be had, the attendance would be increased; this is not borne out by the record.

Twelve meetings of the Executive Board have been held since December 1, 1902, with an average attendance of five.

One amendment was made to the Constitution, viz: To allow all classes of membership to vote and hold office.

I would respectfully request that the President appoint a committee to examine my books before I turn them over to the newly elected Secretary.

(Signed) L. W. EIGHMY, *Secretary.*

ANNUAL REPORT OF TREASURER.

Engineers' Society of Western New York.

GENTLEMEN:—As your Treasurer, it is my pleasure to submit the following report:

RECEIPTS.

From G. B. Bassett, retiring Treasurer	$294.41
From the Secretary and others	571.60
From banks, interest	10.53
Total	$876.54

DISBURSEMENTS.

Rent, October, 1902, to September, 1903, inclusive	$276.00	
Three quarterly assessments, A. E. S.	93.50	
Postage, printing and stationery	93.32	
Binding, magazines, etc.	24.60	
Subscriptions for magazines, etc.	15.20	
Stenographer, typewriting, annual dinner and sundries	55.58	
Erie County Bank Fund	311.10	
Fidelity Bank Fund	7.24	
		$876.54

BALANCE ON HAND.

General Fund	$6.14	
Library Fund	72.30	
Permanent Fund	239.90	
		$318.34

Respectfully,

(Signed) F. N. SPEYER, *Treasurer.*

REPORT OF THE LIBRARIAN.

To the Engineers' Society of Western New York:

The following-named periodicals, magazines, transactions, reports, etc., are regularly received and placed on the shelves:

"American Society of Civil Engineers." (Transactions.)
"American Society of Mechanical Engineers." (Transactions.)
"American Institute of Electrical Engineers." (Transactions.)
"Anales Del Instituto De Injenieros De Chile."
"Association of Engineering Societies." (Journal.)
"Association of Civil Engineers of Cornell University."
"Canadian Society of Civil Engineers." (Transactions.)
"Cassier's Magazine."
"Engineers' Club of Philadelphia." (Proceedings.)
"Engineering News."
"The Dirt Mover."
"The Engineering Magazine."
"Engineers' Society of Western Pennsylvania." (Proceedings.)
"Engineering Index."
"Mineral Survey of the State of Texas."
"Municipal Journal and Engineer."
"Popular Mechanics."
"Railroad Gazette."
"Railway and Engineering Review."
"Railroad Herald."
"State Engineer of New York." (Reports.)
"Street Railway Journal."
"United States Consular." (Reports.)
"United States Geological Survey." (Reports.)
"United States Chief of Engineers." (Reports.)
"United States Coast Survey." (Reports.)
"United States Department of Agriculture on Forestry." (Reports.)
"United States Water Supply and Irrigation." (Reports.)
"Western Society of Engineers." (Transactions.)
"Wisconsin University." (Bulletins.)

As soon as full volumes of these are issued they are bound and placed on the shelves.

In addition to the above, a good many other periodicals are sent to us at irregular times, all of which are preserved for reference.

There are now on the shelves 380 bound volumes and 290 pamphlets. Sixty volumes of periodicals are ready for binding as soon as the finances will admit. Besides these there are in the library upwards of 500 pamphlets, periodicals, transactions, specifications, maps, plans, etc.

There is a complete file of bound volumes of *Engineering News*, with the exception of nine volumes between 1885 and 1891; three of these are complete, with the exception of one number in each volume, which the librarian has been trying for six months to acquire by purchase.

Through the kindness of our members we receive at the close of each year a large number of periodicals, so that we have on hand many duplicates, which are for sale or exchange.

During the past year there has been expended for the library the following sums, viz:

For binding books	$24.60
For subscriptions and sundries	13.07

Respectfully submitted,

W. A. Haven, *Librarian.*

Civil Engineers' Club of Cleveland.

The rooms of the Civil Engineers' Club, in the Arcade, were filled almost to overflowing Tuesday, January 12th, in honor of President Walter C. Parmley, of the Club, the regular meeting being followed by an informal reception to Mr. Parmley, who will leave the city next week to become general manager of the New York Cement Company, with offices in New York City.

Mr. Parmley was elected to the Presidency of the Club last March, and had all but completed his term. He leaves Cleveland, after having been connected with the City Engineer's office since 1896, as engineer of the intercepting sewer system, which is now designed and partially completed. In addition to the management of the New York Cement Company, which is engaged in the manufacture of cement building stones, Mr. Parmley will continue the designing and constructing of concrete and steel engineering work.

At the reception appropriate speeches of regret, congratulation and eulogy were delivered by Robert Hoffman, Mr. Parmley's successor in the City Engineer's Office; ex-City Engineer M. E. Rawson and others, and were replied to by Mr. Parmley. A buffet luncheon was served at a late hour.

The following Nominating Committee for officers for the ensuing year was elected: M. E. Rawson, J. H. Fox, Jas. Ritchie, A. A. Honsberg, A. A. Skeels, G. T. Nelles and W. P. Brown.

Joe C. Beardsley, *Secretary.*

Engineers' Club of St. Louis.

571ST MEETING, ST. LOUIS, MO., DECEMBER 16, 1903.—The annual dinner of the Club was held at the Washington Hotel, President Van Ornum presiding. There were forty-seven members and thirteen guests present.

After the dinner the Club was called to order by the President, who announced the result of the ballot for officers for the year 1904, as follows:

President—J. A. Ockerson.

Vice-President—Robert Moore.

Secretary—R. H. Fernald.

Treasurer—E. E. Wall.

Librarian—E. B. Fay.

Directors—J. L. Van Ornum and E. A. Hermann.

Members of Board of Managers of Association of Engineering Societies —F. E. Bausch and W. C. Toensfeldt.

The President then announced that the annual prize for the best paper read during the year ending July 1, 1903, had been awarded to Mr. C. D. Purdon for his paper on "Railway Grade Reduction," read before the Club, May 6, 1903.

The address of the retiring President, J. L. Van Ornum, upon "Fable and Fact as Factors of Progress," was then presented, and was followed by appropriate remarks by the newly-elected President, J. A. Ockerson, who acted as toastmaster for the evening.

Remarks, both serious and far from serious, were then offered by various members of the Club, including Messrs. Philip Moore, John Laird, R. H. Phillips, C. A. Moreno, L. F. Goodale and others.

Although Rear-Admirai George M. Melville, U. S. N., and Lieut. Godfrey L. Carden, who were to respond to toasts, were unable to be present, much pleasure was given by the remarks of other guests of the evening, namely, Dr. Tarleton H. Bean, Chief of the Department of Forestry, Fish and Game; Col. F. M. De Sousa Aguiar, President of the Brazilian Commission to the Louisiana Purchase Exposition, and Mr. Wong Kai Kah, Vice-Commissioner to the Exposition from China. The remarks of the last-named speaker upon engineering conditions in China, past, present and future, awakened more than ordinary interest and enthusiasm.

R. H. FERNALD, *Secretary.*

572D MEETING, ST. LOUIS, MO., JANUARY 6, 1904.—Held at the Club Rooms, 709 Pine Street, at 8.15 P.M.; President Ockerson in the chair. Present, thirty-five members and eight guests.

The minutes of the 570th and 571st meetings were read and approved, and the minutes of the 359th meeting of the Executive Committee were read.

The question of the continuation of lunches, with the lunch fund showing a deficit, was discussed. Upon motion of Mr. Bryan it was decided to discontinue the lunches until such time as the profits from the *Bulletin* or other sources (not the regular general funds) shall warrant their continuation.

The President was authorized to appoint a committee to prepare a suitable memorial on the death of Mr. George W. Fisher, a charter member of the Club.

The following committees were appointed by the President:

Members of Governing Board of the Associated Technical Clubs of St. Louis—A. H. Zeller and F. E. Bausch.

Committee on Smoke Prevention—Philip N. Moore, Edward Flad, H. H. Humphrey, E. C. Parker and N. W. Perkins.

Committee on Entertainment—F. E. Bausch, T. M. Post and S. E. Freeman.

The paper of the evening, on "Vital Statistics of St. Louis Since 1840," was presented by Mr Robert Moore. Mr. Moore gave a most interesting account of the causes of varying percentages in the yearly death rate; he showed conclusively the continued decrease in the death rate since 1840, as indicated by the following figures:

Total Death Rate per 1000.

1841-50.	1851-60.	1861-70.	1871-80.	1881-90.	1891-1900.
51.47	40.84	30.33	22.26	20.51	18.74

Tables and charts showing the deaths caused by consumption and typhoid fever and the death rate of children under five years of age brought out many important facts, and the relations between the number of deaths from typhoid fever and the opening of certain sewers in St. Louis were clearly demonstrated.

The discussion which followed the reading of the paper was participated in by Messrs. Flad, Wheeler, Ockerson, Turner, Johnson, Humphrey, Swope and others.

Adjourned. R. H. Fernald, *Secretary.*

573d Meeting, St. Louis, Mo., January 20, 1904.—The meeting was held at the Club Rooms, 709 Pine Street, at 8.15 p.m.; President Ockerson in the chair. The minutes of the 572d meeting were read and approved.

Mr. Sherman Worcester Bowen was elected to membership. The President appointed Mr. P. N. Moore, Mr. W. A. Wise and Mr. R. E. McMath as a committee to prepare a suitable memorial on the death of Mr. G. W. Fisher.

Applications for membership were read from Mr. H. H. Morrison, Mr. F. H. Vose and Mr. P. R. Goodwin.

Mrs. S. B. Russell, Chairman of the World's Fair Committee, presented a report embodying the following recommendations:

That a young engineer be installed at the rooms of the Club from May 1 to December 1, 1904, to greet and welcome visiting engineers and give them such directions as would enable them to reach the points of local interest they might wish to see. Also, that a Bell telephone be installed in the rooms of the Club, and that an effort be made to induce the two architectural societies sharing the Club Rooms to share the expense.

That the Club be requested to authorize the committee to call on volunteers from the Club to assist in meeting and entertaining visiting engineers.

That the committee recommend the preparation of a pamphlet consisting of four sections, as follows:

"World's Fair Section."

"Engineering Guide to St. Louis and Vicinity."

"Local Engineering Data."

"Engineers' Club Bulletin."

Upon motion of Professor Van Ornum, the Club indorsed the plan outlined by the committee.

The paper of the evening, upon "International Morality and the Panama Question," was then presented by Prof. Arthur O. Lovejoy, Professor of Philosophy at Washington University.

In showing the action of the United States Government to be justified, the following points were brought out by the speaker: Has one part of a country the right to secede? Morally, opinion is generally in favor of the right of secession, but this may be easily counterbalanced by reasons, such as geographical conditions, manners, etc., of the different peoples forming the whole. . . . . Panama has long been the cow which Colombia has milked, by taxes, etc. United States intervention was a good thing to the people of that country, and to the whole world, because of its final consequences. Compare United States intervention in the Panama question with the aid rendered this country by France in the War for Independence.

There is a moral right to intervene where what happens in the back yard of a neighboring nation affects the health and well-being of a nation. Inasmuch as there is no power with the right of eminent domain, then the strong powers can and should, if with pure intentions, intervene, to see that the country doing a wrong to the whole is restricted for the benefit of the majority. In the Panama question it is right that the canal should be open for the use of the world by the nation through whose territory it passes, and if that nation refuses to permit another nation to do that work for it under reasonable conditions and offer a very liberal indemnity, is there not an international right of eminent domain morally?

Mr. Robert Moore discussed the paper at some length, bringing out many points of interest. He said, in part:

"If we look at this matter in the light of general welfare, either our own, or Panama, or the whole of South America, that there was no justification whatever on the part of the Government of Colombia for blocking the way as they intended to do, and still less justification when we take into account the very obvious reason for the delay in order to extort a larger price from the United States, both by virtue of the lapse of the franchise of the Frenchmen and the proportion which we offered to the Frenchmen of $10,000,000. I think the whole matter entirely justified on the whole ground of the interest of America and of right. . . . . The whole talk of the Panama secession as a speculation of a lot of gamblers is extremely silly as affecting the United States in the case."

The Club was pleasantly entertained by the remarks of one of the guests of the evening, Mr. A. Q. Prada, of Colombia, who took exceptions to the views previously presented. The following points were brought out: No man can find anything that would indicate that Panama was disgusted with Colombia. It was an independent State with its own laws. One State cannot oppress another while both States have equal rights. . . . . Colombia has never done anything to mar her standing as a nation, and she is to-day one of the most promising republics in the world, taking into account her short political existence of eighty odd years and the question of how many things Colombia has accomplished. . . . . The treaty, as written and prompted by the United States at Washington, was not acceptable to Colombia, as Constitutional objections were involved. The Bogota Government, upon refusing the treaty, did not intend to quash proceedings and prevent the United States from building the canal. She

was willing to make a treaty more satisfactory to both parties. The treaty with France did not involve the questions; the treaty with the United States did. France was willing to take a concession for ninety-nine years. The United States did not want anything but perpetual sovereignty, which the Colombian Constitution prohibited. The United States would feel affronted if a European country offered to buy a part of its territory. Colombia felt the same way. They did not wish to dismember their country. If the United States had been willing to build the canal under the French proposition, the canal would to-day be nearly completed. But the United States wanted too much: wanted the territory itself, which Colombia would not assent to.

The paper was further discussed by Professor Van Ornum, Mr. Ernest McCullough and Mr. Robert Burgess, the last speaker stating that: "In some three weeks in the city of Panama, in talking with people and their acquaintances, I got the impression that Panama was very closely tied to the rest of the country, but they did not feel that they really belonged to it. They are almost universally in favor of the new government."

A vote of thanks of the Club was extended Professor Lovejoy and the gentleman from Colombia (Mr. A. Q. Prada) for their interesting and instructive addresses.

Adjourned. R. H. FERNALD, *Secretary.*

Technical Society of the Pacific Coast.

REGULAR MEETING, SAN FRANCISCO, CAL., DECEMBER 4, 1903.—Called to order at 8.30 P.M. by President D. C. Henny.

The minutes of the last regular meeting were read and approved.

The following names were elected to membership: Joseph Jacobs, civil engineer; Robert Hauxhurst, Jr., civil engineer; M. C. Couchot, civil engineer; and instructed to be added to the list.

The election of a Nominating Committee to select a ticket of officers for the ensuing year being in order, the following members were chosen and elected in due form, and the Secretary was instructed to notify them of their election and their duties: Chas. D. Marx, chairman; Marsden Manson, F. C. Herrmann, Hermann Barth and Hermann Kower.

The adoption of the resolutions to amend the By-laws to the extent of confining the meetings of the Society to two during the year, as recommended by the committee at the last November meeting, and there read for the first time to be ratified and approved at the December meeting, was then taken up in regular form.

The Secretary read the amendments as proposed, and the Society acted upon each individually, retaining the general proposition embodied in the recommendation, but introducing alterations in minor details, adopting by vote the amendments in regular order, as follows:

A—Strike out Section 2, Article I, of the By-laws, which reads:

"SECTION 2. The regular stated meetings of the Society shall be held on the first Friday of each month, at the hall of the Society, at 8 P.M."
and substitute therefor:

"The regular stated semi-annual meetings of the Society shall be held as follows: One, the spring meeting, either in April or May, and the other,

the fall meeting, either in September or October of each year, the precise date and place of meeting to be left to the discretion of the Board of Directors, who shall arrange a program and announce such date and place at least thirty days before the meeting, which is to be held for the purpose of reading and discussing technical papers, as well as for stimulating professional and social intercourse among members."

B—Amend Section 3, Article I, by placing before the present section the following words:

"Monthly stated meetings may be held on the first Friday of any month, excepting that of July, for the transaction of the ordinary business of the Society and for informal topical discussions."

C—Strike out all of Section 5, Article I, which would be in conflict with Section 2 as now amended.

Amendments A, B and C, as here recorded, were approved by vote, and the Secretary was instructed to incorporate them in the By-laws.

No further business appearing, the meeting adjourned.

Otto von Geldern, *Secretary.*

Regular Meeting, San Francisco, Cal., January 2, 1904.—Called to order at 8.30 P.M. by Past-President Dickie.

The minutes of the last regular meeting of December were read and approved.

The Secretary of the Nominating Committee reported as follows:

San Francisco, December 26, 1903.

Your Committee on Nominations of Officers for the ensuing term desires to make the following report:

For President—Geo. W. Dickie.

For Vice-President—Franklin Riffle.

For Secretary—Otto Von Geldern.

For Treasurer—E. T. Schild.

For Directors—C. E. Grunsky, L. J. Le Conte, H. D. Connick, Adolf Lietz and Carl Uhlig.

Respectfully submitted.

F. C. Herrmann, *Secretary of Committee.*

The Secretary was instructed to prepare these names for ballot, in time for the annual meeting to be held January 22, 1904, and the Chairman appointed the following tellers: George H. Wallis and Leon S. Quimby.

Past-President Dickie explained at length a movement on foot by the Chamber of Commerce of London to carry on an extensive course of technical lectures in the principal cities of the United States. These lectures are elaborately prepared and illustrated by numerous costly lantern slides, and touch upon almost every field of technical activity. The expenses are to be borne by Mr. Morgan, including the renting of the hall for the purpose and the apparatus for illustration. Mr. Dickie desired to know whether the Society would agree to entertain any proposition encouraging the holding of these lectures which would be absolutely without any expense; the matter had been laid before him by men prominently connected with this enterprise, and he asked whether any inducements would be held out by the Technical Society to give it its support.

Colonel Wallis thought the idea a very good one and suggested that

the Society agree to hold this course of lectures in San Francisco under its auspices, and moved that Mr. Dickie inform the patrons that the Technical Society, being desirous of encouraging and supporting this movement, agrees to hold these lectures in its name and under its protection at any future time, and in any manner that the new Board of Directors, who are about to go into office, may deem expedient and desirable. The motion was carried.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Annual Report of the Secretary for the Year 1903.

I have the honor to submit to the Society, through its Board of Directors, the following report, showing the condition of the Society on January 22, 1904, the date of the regular annual meeting:

The present total membership is 158, as follows:

Honorary members	2
Life members	3
Members	136
Associates	17
Total	158

Of these there are:

Resident members	86
Resident associates	55
Non-resident members and associates	17
Total	158

Geographically distributed there are in:

San Francisco and vicinity	107
Northern California	26
Southern California	5
Arizona	1
Colorado	1
District of Columbia	1
Hawaii	3
Illinois	1
Massachusetts	1
Nevada	2
New York	1
Oregon	2
Washington	1
Utah	1

FOREIGN.

Australia	1
Africa	2
British Columbia	1
England	1
Total	158

Professionally divided there are:

Architects	8
Builders	10
Chemists	2
Civil Engineers	65
Draughtsmen	4
Electrical Engineers	5
Instrument Makers	2
Manufacturers	7
Mechanical Engineers	27
Military Engineers	3
Mining Engineers	9
Naval Architect	1
Professors of University	5
Scientist	1
Surveyors	9
Total	158

ADMISSIONS IN 1903.

By election:	
Members	10
Associates	3
By reinstatement:	
Members	6
Total	19

MEMBERSHIP OF THE SOCIETY AT THE END OF THE YEAR 1902.

Members and associates	153
Admitted in 1903	19
Total on membership list during the past year	172

LOSS DURING THE YEAR 1903.

Deaths	3
Resignations	8
Suspensions	3
Total loss	14
Carried on membership list during 1903	172
Loss	14
Present membership	158
Gain in 1903	5

DEATHS DURING 1903.

George F. Allardt,
Dana Harmon,
F. B. Morse.

During the year the Society added to it's membership the following: By election:

MEMBERS.

1. M. C. Couchot, Civil Engineer, San Francisco, Cal.
2. Robert Hawxhurst, Jr., Civil Engineer, Hawaii.
3. L. A. Hicks, Civil Engineer, Oakland, Cal.
4. Joseph Jacobs, Civil Engineer, San Francisco, Cal.
5. August Kempkey, Jr., Civil Engineer, Oakland, Cal.
6. Charles List, Civil Engineer, San Francisco, Cal.
7. R. W. Myers, Electrical Engineer, San Francisco, Cal.
8. George W. Nichols, Electrical Engineer, Round Mountain, Cal.
9. Oliver N. Sanford, Civil Engineer, San Francisco, Cal.
10. J. J. Welsh, Architect, San Francisco, Cal.

ASSOCIATES.

1. S. Giletti, Concrete Builder, San Francisco, Cal.
2. George Stone, President Pacific Portland Cement Co., San Francisco, Cal.
3. Rudolph J. Taussig, President Mechanics Institute, San Francisco, Cal.

By reinstatement:

MEMBERS.

1. Gustav A. Behrnd, Architect, San Francisco, Cal.
2. H. L. Demeritt, Civil Engineer, San Francisco, Cal.
3. H. F. Eckert, Structural Engineer, San Francisco, Cal.
4. Franz M. Goldstein, Draughtsman, San Francisco, Cal.
5. F. A. Koetitz, Civil Engineer, San Francisco, Cal.
6. James T. Ludlow, Mechanical Engineer, San Francisco, Cal.

RESIGNATIONS DURING THE YEAR 1903.

1. Ross E. Browne, Mining Engineer, South Africa.
2. Thomas W. Butcher, Builder, San Francisco, Cal.
3. B. C. Donham, Civil Engineer, Korea.
4. John McGilvray, Builder, San Francisco, Cal.
5. Erland Gjessing, Stenographer, New York, N. Y.
6. Frank H. Masow, Builder, San Francisco, Cal.
7. A. S. Riffle, Civil Engineer, Arizona.
8. Charles E. Wetherell, Surveyor, San Francisco, Cal.

SUSPENSIONS DURING THE YEAR 1903.

1. J. B. Crockett, San Francisco, Cal.
2. O. H. M. Denio, Vallejo, Cal.
3. Peter E. Lamar, Hawaii.

HONORARY MEMBERS.

1. Colonel C. Seaforth Stewart, Washington, D. C.
2. Commodore Theodore D. Wilson, Washington, D. C.

LIFE MEMBERS.

1. George W. Dickie, San Francisco, Cal.
2. George H. Evans, Breckenridge, Col.
3. E. J. Molera, San Francisco, Cal.

The following subjects were read and discussed officially during the past year:

1. "The Water and Forest Irrigation Bill," by the Society.

2. "Armored Concrete Piles and Wharves,' by Emile Villet.

3. "The Giletti System of Concrete and Iron Construction," by S. Giletti.

4. "Building of an Iron Wharf at Ocos, Guatemala," by Charles List.

5. "Description of the Holmes and Uhlig Method of Wharf Building," by Carl Uhlig.

6. "The Work of the United States Department of Agriculture in Irrigation Investigation," by Elwood Mead.

7. "Projects for a Water Supply for the City of San Francisco," by Marsden Manson and C. E. Grunsky.

8. "Impressions Made by Recent Engineering Works of the East," by C. E. Grunsky.

9. "Methods of Refrigeration," by James T. Ludlow.

10. "Regarding Patent Laws and Their Necessity," by George W. Dickie.

11. "The Administration of Patent Laws," by John Richards.

12. "Amending the By-laws as to Frequency of Meetings and Regulating Semi-annual Meetings of the Society, Committee and Society at Large."

13. "The Works of the Pacific-Portland Cement Company at Suisun, and Excursion to the Works by the Society."

OTTO VON GELDERN, *Secretary.*

Boston Society of Civil Engineers.

BOSTON, MASS., JANUARY 14, 1904.—A special meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock P.M., Vice-President Frederick Brooks in the chair; one hundred and two members and visitors present.

Mr. George B. Francis presented two papers, which were fully illustrated by lantern views. The first paper was on "Timber Crib Foundations," and was discussed by Messrs. J. W. Rollins, J. P. Snow, William Parker and others. The second paper read was entitled "Description of the Construction of a Double-Track, Third-Rail Electric Road between Scranton and Wilkesbarre, Pa."

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., JANUARY 27, 1904.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.30 o'clock P.M., President Hollis in the chair; one hundred and twenty-two members and visitors present, including ladies.

The records of the last regular and the special meeting of January 14th were read and approved.

Messrs. William W. Locke, J. Waldo Smith and George Stephen were elected members of the Society.

On motion of Mr. Manley, the President was requested to appoint a committee of three to report to the meeting the names of five members to serve as a committee to nominate officers for the ensuing year. The President appointed the following as that committee: Henry Manley, F. C. Coffin and Leonard Metcalf.

Later in the meeting this committee reported the following names as members of the Nominating Committee: Messrs. A. H. French, C. T. Main, George Bowers, H. K. Higgins and J. L. Howard, and on motion they were duly elected.

The Secretary reported for the Board of Government that at a meeting of the Board, held December 21, 1903, under authority of By-law 15, it was voted to establish the Sanitary Section of the Boston Society of Civil Engineers, in accordance with the petition of Freeman C. Coffin and thirteen other members of the Society.

The Section has held one or more meetings and has adopted the following code of By-laws, which has been approved by the Board:

ARTICLE I.

SECTION 1. The object of the Sanitary Section of the Boston Society of Civil Engineers shall be the advancement of knowledge relating to the science and practice of sanitary engineering.

ARTICLE II.

SECTION 1. The membership of the Sanitary Section shall consist of members and associates.

SEC. 2. Those engaged in the design, construction or maintenance of sanitary works, or other persons qualified to aid in the advancement of knowledge relating to the science and practice of sanitary engineering shall be eligible as members.

SEC. 3. Other persons interested in the objects of the Section and desirous of being connected with it shall be eligible as associates after election as associates in the Society.

SEC. 4. Members only shall be eligible to office and entitled to the right to vote.

ARTICLE III.

SECTION 1. Members and associates of the Boston Society of Civil Engineers shall be entitled to membership in this Section as members and associates, respectively, upon making written application to the Executive Committee of the Section.

SEC. 2. Any person other than a member of the Boston Society of Civil Engineers who shall make application for admission to the Section as member shall embody in his application a concise statement of his qualifications for membership, and his application shall be indorsed by two members of the Section.

SEC. 3. Applications for membership under section 2 shall be considered by the Executive Committee, who shall present them to the Board of Government of the Society, provided a majority of the committee are in favor of such action, and if the applications are approved by the Board of Government they shall be presented to the Section for ballot.

SEC. 4. If the applicant receives two-thirds of the ballots cast, he shall be declared elected, and shall become a member on paying the required entrance fee and signing, within two months, an agreement to be governed by the By-laws of the Section and the Constitution and By-laws of the Society so far as they apply to the Section.

SEC. 5. Members and associates of the Boston Society of Civil Engineers, who are not enrolled as members of the Section, shall be entitled to attend all meetings of the Section and to take part in the discussion of papers on professional subjects, but shall have no vote.

ARTICLE IV.

SECTION 1. The officers of this Section shall be a Chairman, Vice-Chairman and Clerk.

The general government of the Section shall be vested in an Executive Committee, consisting of the President of the Boston Society of Civil Engineers, the Chairman, Vice-Chairman, Clerk and three other members of the Section.

SEC. 2. The Chairman of the Section shall represent the Section at the meetings of the Board of Government of the Boston Society of Civil Engineers, with the privilege accorded under its By-laws.

SEC. 3. The term of office of all officers and committees shall be one year, but shall continue until their successors are elected.

SEC. 4. All officers and committees shall assume their duties immediately after the close of the meeting at which they have been elected.

ARTICLE V.

SECTION 1. The Chairman shall have a general supervision of the affairs of the Section. He shall preside at meetings of the Section. In case of his absence or a vacancy in his office, the Vice-Chairman shall discharge his duties.

SEC. 2. The Executive Committee shall have control of the management of the Section, subject to the action of the Section at any meeting, and shall make the necessary arrangements for all meetings. All questions in Executive Committee shall be decided by a majority vote, and four members shall constitute a quorum. Meetings of the Executive Committee shall be held before each business meeting of the Section and at the call of the Section Chairman, or in his absence or inability to serve, at the call of the Vice-Chairman.

SEC. 3. The Clerk shall keep the records of the meetings of the Section and of the Executive Committee, and perform such other duties as are herein prescribed and as may be required by the Executive Committee. He shall prepare and transmit to the Secretary of the Boston Society of Civil Engineers notices of all meetings, copies of the records of all meetings and of all papers and discussions.

SEC. 4. No expenditure shall be made or financial obligation incurred by any officer or committee of the Section, for which the Society will be responsible, without previous authorization by the Board of Government or President of the Society.

ARTICLE VI.

SECTION 1. The annual meeting of the Section shall be held in Boston on the first Wednesday in March, at which meeting the annual reports for the preceding year shall be presented and the officers for the ensuing year elected.

SEC. 2. The officers and other members of the Executive Committee shall be elected at this meeting by written ballot, from nominations made from the floor, or submitted in writing previous to the meeting and indorsed by at least ten members.

SEC. 3. The regular meetings of the Section shall be held on the first Wednesday of the months of March, June, October and December.

SEC. 4. Special meetings of the Section may be held at the call of the Chairman. At special meetings no applications for membership shall be acted upon, nor any business transacted, unless announced in the call for the meeting and upon recommendation of the Executive Committee.

ARTICLE VII.

SECTION 1. Proposed amendments to these By-laws must be submitted in writing to the Executive Committee, and shall be presented to the Section at a regular meeting, if so decided by vote of the Executive Committee. The Executive Committee shall, however, bring before the Section any proposed amendment at the written request of ten members.

SEC. 2. Announcement of a proposed amendment which is recommended by the Executive Committee or by ten members of the Section, shall be given by printing the amendment in the notice of the regular meeting. A two-thirds vote of the members present and voting shall be necessary for the adoption of the amendment.

SEC. 3. All amendments to these By-laws must receive the approval of the Board of Government of the Boston Society of Civil Engineers before taking effect.

Mr. F. W. Hodgdon submitted the following motion, which had been printed in the notice of the meeting: Voted, that the Society indorse and recommend the changes in the Boston Building Laws proposed by

the Committee of the Society in its report made at the meeting held December 16, 1903; and that the same committee be instructed to take the necessary action to submit the proposed changes, with the indorsement of the Society, to the Mayor, and to appear in behalf of the Society, if in their opinion it is necessary, before the proper legislative committee, in support of the proposed changes.

On motion of Mr. Howland, it was voted to postpone the consideration of the motion until the next meeting.

Mr. Henry Manley was appointed a committee to make the necessary arrangements for the annual dinner of the Society.

On motion of Mr. Adams, the thanks of the Society were voted as follows: To Messrs. R. L. Fosburg & Sons, Contractors, and their Superintendents; and to the United Shoe Machinery Company and its Supervising Architect, for courtesies shown the members of the Society on the occasion of the visit to the new buildings of the latter company, at Beverly, Mass., on January 14th. Also, to Mr. Walter B. Snow, Superintendent of the B. F. Sturtevant Company, for courtesies shown on the occasion of the visit to the works of that company on the 27th inst.; also to Mr. B. F. Simmons, Electrical Engineer, N. Y., N. H. & H. R. R., for courtesies shown on the occasion of the visit to the new power house of the railroad company at Hyde Park, Mass.

Mr. George A. Kimball gave a very interesting talk, illustrated by lantern views, entitled "Notes on Passenger Traffic in Some Foreign Cities." A discussion followed Mr. Kimball's entertaining and instructive talk, in which a number of members took part. Gen. William A. Bancroft, President of the Boston Elevated Railway Company, also briefly addressed the meeting, contrasting the elevated roads in Boston with those in foreign cities.

Adjourned. S. E. TINKHAM, *Secretary*.

Engineers' Club of Minneapolis.

172D MEETING, MINNEAPOLIS, MINN., JANUARY 18, 1904.—At the invitation of the Commercial Club, the meeting was held in their Rooms, 9th floor, Andrus Building.

During the first part of the evening the Club listened to an address by Mr. Warren H. Manning, of Boston, on "Should Minneapolis Acquire More Park Lands, or Improve What It Has, and How? Mr. Manning believed in developing what land Minneapolis already has.

The annual meeting of the Club followed. All of those whose names were proposed at the 160th meeting were elected to membership. The following were proposed for membership: Joseph Lane, W. H. Kavenaugh, E. S. Oliver, R. S. King, A. F. Norcross, M. G. Hooper, H. W. Dixon, A. S. Cutler, Trithiof Magnusson, E. B. Newcombe, Jas. S. Boustead, Austin G. Johnson and Louis Clousing.

The Secretary's report was then given as follows:

ANNUAL REPORT OF THE SECRETARY.

The Secretary submits the following report for the past year, 1903:

Nine meetings were held, as follows:

163d Meeting, January 26th. This was the annual meeting, at which reports of the officers of the previous year were made, and new officers elected. A paper was delivered by Mr. E. P. Burch regarding the old power house at St. Anthony Falls, this paper being illustrated by a number of lantern slides. Prof. W. R. Hoag also showed fifty views of "Good and Bad Roads." Mr. F. E. Rice showed twenty-five views of the new Milwaukee bridge during construction.

164th Meeting, February 16th. This meeting consisted of a dinner given at the Commercial Club Rooms. Addresses were made by Hon. J. C. Haynes, Geo. W. Sublette, Prof. Fred S. Jones, Andrew Rinker, Prof. Geo. D. Shepardson, Geo. W. Cooley and others. Mr. Wm. W. Redfield acted as toastmaster.

165th Meeting, March 16th. This meeting was held in the County Commissioners' Room, and was devoted to papers by Mr. C. A. P. Turner, on "County Bridges," and Prof. W. R. Hoag, on "The Work of the State Drainage Commission." The latter paper was fully illustrated by lantern slides.

166th Meeting, April 20th. Held in the Room of the County Commissioners. A paper was read by Wm. W. Redfield, on the "Panama Canal." Mr. L. S. Gillette recited some of his experiences on his recent trip through the West Indies.

167th Meeting, May 22d. That date being the twentieth anniversary of the organization of the Club, a special meeting was held at the hall, 15 South Seventh Street. Entertainment was provided by Hilyard's colored quartette, St. Paul. Mr. W. H. Eustis delivered a very entertaining address on the "Hawaiian Islands." Refreshments were served.

168th Meeting, October 7th. A visit was made by the Club to the new Chamber of Commerce building; a thorough examination of the power and heating plant was made. Refreshments were served.

169th Meeting, November 16th. Held in the County Commissioners' Room. The meeting was addressed by Mr. Francis M. Henry, on "Changing the Course of Bassett's Creek." Discussions followed by Messrs. Ilstrup, Sublette and others.

170th Meeting, December 5th. The Club visited the plant of the Minnesota Sugar Company, at St. Louis Park.

171st Meeting, December 26th. The Club made a visit of inspection of the mechanical equipment at the Glass Block. Mr. F. M. Overholt explained some of the new and interesting machinery which has been installed there. Light refreshments were served.

The attendance at all of these meetings has been comparatively large.

Only one paper given before the Association this year has been published in the Journal. This is to be regretted, as it is desirable that the Club have as good representation as possible in the Journal.

The meetings of the year have been devoted more to visits and entertainments than literary features.

The Club mourns the loss through death, of one of its charter members, Mr. W. D. Van Duzee, for several years honorary member.

The Club has grown considerably in numbers. At the beginning of the year we had sixty-two active members. During the year forty were elected

to membership. One member has resigned, two have been dropped on account of their having left the city and their whereabouts not being known. Our present membership is 100, or a gain of 75 per cent. for the year.

Respectfully submitted,

J. B. GILMAN, *Secretary.*

The Treasurer's report was as follows:

ANNUAL REPORT OF THE TREASURER, 1903.

MR. H. B. AVERY, President, Engineers' Club of Minneapolis, City.

DEAR SIR:—I beg to submit the following statement of the receipts and expenditures of the Club for the past year:

Balance in cash from 1902	$97.85
Dues of seventy-nine members, 1903	237.00
Dues of nine members, 1904	27.00
Total receipts to date	$361.85
Typewriting and stenographic work	$5.80
Reception Committee badges	1.80
Music, entertainment, etc.	52.25
Stationery	24.25
Printing	42.75
JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES	187.10
Photographs	3.00
Lantern slides illustrating papers	7.50
Work on bookcases and drayage on same	4.80
Hall rent	7.00
Total expenditures to date	$336.25

I would state that all bills, as far as I know, are paid, the only possible exception being the notices for this meeting. Also, $30.20 of this year's expenditures represent the last quarter's dues for the JOURNAL for the year 1902, which I have paid this year.

At the present time we have a cash balance of $25.60.

Respectfully submitted,

B. H. DURHAM, *Treasurer.*

The Librarian and Chairman of Standing Committees reported briefly. J. M. Tate, Chairman of the committee appointed to prepare an exhibit for the Louisiana Purchase Exposition, made a report, showing that very favorable progress had been made.

The election of officers for the ensuing year was then held, which resulted as follows:

President—H. B. Avery.

Vice President—E. P. Burch.

Secretary—J. B. Gilman.

Treasurer—B. H. Durham.

Librarian—W. W. Redfield.

Representative to the Association of Engineering Societies—Prof. W. R. Hoag.

Finance Committee—C. F. Pillsbury and J. M. Tate.

Upon motion by Mr. Redfield, a vote of commendation was given to the Secretary and Treasurer for their careful work during the past year. The meeting then adjourned.

J. B. GILMAN, *Secretary*.

Montana Society of Engineers.

HELENA, MONT., JANUARY 8 AND 9, 1904.—The fourteenth annual meeting of this Society was held on Friday and Saturday. Friday was devoted to a trip to the Electric Power Plant, located at Canyon Ferry, about eighteen miles from Helena. There the engineers were welcomed by Mr. M. H. Gerry, Jr., and his assistants, and every courtesy shown them. After several hours' stay, which was devoted to an examination of the power plant and the enjoyment of a fine lunch, the party returned to Helena. Friday evening the engineers and their friends were the guests of President Wickes at a "smoker."

Saturday morning the members of the Society, in a goodly number, assembled at 10 o'clock, in the Rooms of the Business Men's Association, for the transaction of business. President Geo. T. Wickes in the chair. The minutes of the last meeting were read and approved. Applications for membership in the Society were read by the Secretary from the following: Russell H. Wilson, Frank Marion Kerr, Frank Ashton Jones, Lewis Webster Wicks and Alexander N. Winchell. On motion, the Secretary was instructed to send out ballots for these parties, after the approval of their applications by the Trustees. The Secretary presented the ballots on the application of Geo. M. Craven, and Messrs. Carroll and Sizer were appointed tellers to count the same. They reported the ballots favorable, and President Wickes declared Mr. Craven duly elected a member of the Society. The election of officers being the next order of business, Messrs Carroll and Sizer were appointed to count the ballots submitted, and reported a unanimous vote in favor of the following-named persons for the various named offices of the Society for the ensuing year:

President—Geo. E. Moulthrop, Butte.

First Vice-President—Ernest W. King, Bozeman.

Second Vice-President—Malcolm L. MacDonald, Butte.

Secretary and Librarian—Clinton H. Moore, Butte.

Treasurer, and Member of the Board of Managers of the Association of Engineering Societies—Sam'l Barker, Jr., Butte.

Trustees—Chas. H. Repath, Edward L. Blossom and Charles H. Bowman.

President Wickes announced the election of the above-named persons, and, President Moulthrop not being present, First Vice-President King took the chair. The annual reports of the Secretary and Treasurer were read and referred, and, after various items of business of a minor character, the Society took a recess till 2 o'clock P.M.

The afternoon session was devoted to the reading of the President's annual address, having for its subject "Early Surveying Reminiscences in the West," and the discussion of various subjects belonging to the engineering profession, confined chiefly to the works of Montana engineers during the past year in this State. Many valuable statements were made and much interest elicited. The Secretary was instructed to prepare a suitable report of the annual meeting in addition to the journal minutes. The Society's appreciation of the various courtesies shown its members by the citizens of Helena was expressed by a unanimous vote, and one of the most successful and pleasant annual meetings of the Society then adjourned. A banquet was held Saturday evening, at the Hotel Helena, with the usual results.

CLINTON H. MOORE, *Secretary*.

Association of Engineering Societies.

Vol. XXXII. FEBRUARY, 1904. No. 2.

PROCEEDINGS.

Technical Society of the Pacific Coast.

Annual Meeting, San Francisco, Cal., January 22, 1904.—Called to order at 8.30 o'clock P.M. by Past-President Manson.

The tellers appointed to open and count the ballots for officers for the ensuing year reported that fifty-eight votes had been cast, and that each one of the candidates had received fifty-eight votes.

The Chairman thereupon announced that the following members had been elected, and that the Secretary inform them by letter of their election to office:

President—Geo. W. Dickie.

Vice-President—Franklin Riffle.

Secretary—Otto von Geldern.

Treasurer—E. T. Schild.

Directors—C. E. Grunsky, L. J. Le Conte, A. D. Connick, Adolf Lietz and Carl Uhlig.

The Secretary's and Treasurer's reports were then read.

These reports were ordered received and placed on the minutes as a part thereof.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Directors' Meeting, San Francisco, Cal., February 1, 1904.—Held in the café of the Call Building, after a dinner given by President Dickie. Present, Directors Dickie, Riffle, Schild, Grunsky, Connick, Lietz, Uhlig and von Geldern.

The following committees were appointed:

Executive Committee—Franklin Riffle, Chairman; C. E. Grunsky, Carl Uhlig and H. D. Connick.

Finance Committee—L. J. Le Conte, Adolf Lietz and Carl Uhlig.

Members on the Board of Managers of the Association of Engineering Societies—George W. Dickie and Otto von Geldern.

The Secretary reported that the Board had accepted two lectures at the last meeing:

"Radium and Radio-Activity," by Prof. Edward Booth, for February 5, 1904.

"Herbert Spencer: His Synthetic Philosophy," by F. P. Medina, for March 4, 1904.

The Secretary was instructed to issue a circular calling upon certain members for papers for the spring meeting. It was agreed among the Directors to hold it either on the second or third Thursday of May. Beginning on a Thursday evening, the meeting will last through Friday and Saturday, and close with a banquet on Saturday night.

The Board will be called at an early date to go into the details of making the necessary arrangements for the meeting.

The meeting thereupon adjourned, to be called by the President.

OTTO VON GELDERN, *Secretary.*

REGULAR MEETING, SAN FRANCISCO, CAL., FEBRUARY 5, 1904.—Called to order at 8.30 o'clock P.M. by President Dickie, who explained that the usual business would be suspended; that the evening had been set aside for a public lecture, to which the friends of the Technical Society were invited. He expressed his satisfaction in being able to greet so large an assembly, and introduced the lecturer, Prof. Edward Booth, of the University of California, who entertained the audience for over an hour on the subject of "Radium and Radio-Activity," dwelling upon all the noteworthy and interesting features of the latest researches. After the lecture he exhibited a number of samples, shadow pictures and apparatus in illustration of his lecture.

The meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

Engineers' Club of St. Louis.

574TH MEETING, ST. LOUIS, MO., FEBRUARY 3, 1904.—Held at the Club Rooms, 709 Pine Street, at 8 P.M.; President Ockerson presiding. There were forty-two members and ten guests present.

The minutes of the 573d meeting were read and approved, and the minutes of the 361st meeting of the Executive Committee were read.

Upon motion of Mr. S. B. Russell, the Secretary of the Club was appointed a member of the World's Fair Committee.

Messrs. H. H. Morrison, P. R. Goodwin and F. H. Vose were elected to membership in the Club.

The President appointed Mr. A. L. Johnson on the Entertainment Committee in place of Mr. S. E. Freeman, who resigned, owing to absence from the city.

Mr. Julius Pitzman presented a paper upon "Protection of the American Bottom Against Overflow, and Regulation of the Mississippi in the Harbor of St. Louis."

After extended discussion by Mr. Robert Moore, Mr. Helm, Mr. Pitzman and others, the meeting adjourned.

R. H. FERNALD, *Secretary.*

575TH MEETING, ST. LOUIS, MO., FEBRUARY 17, 1904.—Held at the Club Rooms, 709 Pine Street, Vice-President Moore presiding.

There were present twenty-two members and eight guests.

The minutes of the 574th meeting were read and approved, and the minutes of the 362d meeting of the Executive Committee were read.

The application of Knud Henrick Jacobsen for membership in the Club was read and referred to the Executive Committee.

A letter from Mr. Chas. Warren Hunt, Secretary of the International Engineering Congress, was read, extending an invitation to the Engineers' Club of St. Louis, to participate in the meetings of the Congress, to be held at the Universal Exposition, October 3 to 8, 1904.

Mr. Robert Burgess presented a paper upon "The Inter-Continental Railway." The paper was interestingly illustrated by lantern slides and maps, and brought out discussion by Messrs. Wheeler, Robert Moore, Bryan and Turner.

The thanks of the Club were extended by Mr. Moore to Mr. Burgess for his able and interesting presentation of the subject.

Adjourned.

R. H. Fernald, *Secretary.*

Civil Engineers' Club of Cleveland.

Cleveland, Ohio, February 9, 1904.—The meeting was called to order by Vice-President B. L. Green. Mr. Reginald A. Wright was elected to active membership. Mr. G. T. Nelles, Chairman of the Nominating Committee, reported the following nominations of officers for the ensuing year: President, Alexander E. Brown; Vice-President, Dr. Dayton C. Miller; Secretary, Joe. C. Beardsley; Treasurer, Robert Hoffman; Librarian, Charles O. Palmer. For Directors—Walter M. Allen and Harry S. Nelson.

Two amendments to the Constitution were introduced, as follows:

Section 3, Article IV.

Page 9.

At the end of said Section 3 add the following words: "Except in case of the resignation of an active member, whose long and efficient service in the Club, in the judgment of the Executive Board, deserves special recognition and acknowledgment. In such case said Board may, at its discretion, ask such member to withdraw his resignation, and if complied with, shall cause his name to be transferred to the retired list of active members, which is hereby authorized. He shall thereafter be exempt from all fees and dues of the Club, but shall be entitled to all the rights and privileges heretofore enjoyed as an active member, except the right to vote and hold office."

Such membership shall not include the Journal of the Association of Engineering Societies, except upon payment of its actual cost to the Club by such member. The Secretary shall serve written notice on such person of his transfer of membership, as per form B B, in the Appendix.

Signed by M. E. Rawson, Joseph Leon Gobeille and Chas. W. Hopkinson.

Section 7, Article VI.

Page 12.

The third sentence to be stricken out and the following inserted in lieu thereof: "The permanent fund shall not be expended for any purpose, except on the unanimous vote of the Executive Board, confirmed by letter-ballot of the Club, in which two-thirds of the legal ballots cast shall be in favor of such expenditure."

Page 13.

The eighth sentence to be stricken out and the following inserted in lieu thereof: "No money shall be transferred from one fund to another, unless so ordered by unanimous vote of the Executive Board, confirmed by letter-ballot of the Club, in which two-thirds of the legal ballots cast shall be in favor of such transfer."

Signed by B. L. Green, Robt. Hoffman and Joe. C. Beardsley.

A resolution was adopted to pass these amendments to letter-ballot.

A resolution was also adopted requesting the Chairman to appoint a committee of three to inquire into the proposed action of the Legislature relative to the prevention of the pollution of lakes and streams as embodied in the bill of Senator M. W. Harvey; this committee to report at the next regular meeting. The Chairman appointed on this committee Major Kingman, Mr. Ritchie and Mr. Hoffman.

The paper of the evening, "Bituminous Coal Mining," was read by Mr. F. C. Green, and was followed by an extended discussion.

JOE. C. BEARDSLEY, *Secretary.*

Association of Engineering Societies.

Vol. XXXII. **March, 1904.** No. 3.

PROCEEDINGS.

Technical Society of the Pacific Coast.

Regular Meeting, San Francisco, Cal., March 4, 1904.—Called to order at 8.30 p.m. by President Dickie, who stated that the meeting was a general one and for the purpose of listening to an address other than technical. He thereupon introduced Mr. F. P. Medina, member of the Technical Society, who delivered an interesting lecture on "The Synthetic Philosophy of Herbert Spencer," a subject of much interest to the ladies and gentlemen present, who expressed their appreciation by an earnest attention.

The President expressed the thanks of the Society for the courtesy of Mr. Medina.

It was announced from the chair that the following names had been added to the membership list by election:

MEMBERS.

1. Lee S. Griswold, Draughtsman, San Francisco, Cal.
2. John W. Carey, Architect, San Francisco, Cal.

ASSOCIATE MEMBER.

1. W. F. Roloff, Mine Worker, Shasta County, California.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Montana Society of Engineers.

The regular monthly meeting of the Society was held in the Society Room, Tuttle Block, February 13, 1904. The meeting was called to order at 8.30 p.m., there being a quorum present; President Moulthrop in the chair. The minutes of the annual meeting, held at Helena, January 8th and 9th, were read and approved. An application for membership in the Society from Frank S. Mitchell was read, approved and the Secretary instructed to send out the ballots for the same. The Secretary reported the receipts of ballots pertaining to the applications of Alex. N. Winchell, Russell A. Wilson, Francis M. Kerr, Frank A. Jones and Lewis W. Wickes. The President appointed as tellers R. R. Vail and Robert A. McArthur to count the ballots, and they reported the unanimous election of the above-named candidates. A general discussion of various engineering topics occupied the time till the meeting adjourned.

Clinton H. Moore, *Secretary.*

Boston Society of Civil Engineers.

Boston, February 17, 1904.—The regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.45 o'clock P.M.; Vice-President Frederick Brooks in the chair. One hundred and fifteen members and visitors present.

The record of the last meeting was read and approved.

Messrs. Ralph E. Curtis, William W. Drummond, Harrison P. Eddy, Henry W. Fenno, Chester J. Hogue, Edward H. Kitfield, Edward S. Larned, Walter E. Parker, Fred M. Randlett and Walter C. Whitney were elected members of the Society.

The Secretary read the memoirs of William C. Ogden and of Frank P. Johnson, which had been prepared by committees of the Society.

The Chair announced the death of George A. Ellis, a member of the Society, which occurred on December 27, 1903, and on motion the President was requested to appoint a committee to prepare a memoir. The President has appointed Mr. R. C. P. Coggeshall as that committee.

The Secretary read a communication from the Secretary of the committee in charge of the International Engineering Congress extending an invitation to the members of this Society to participate in the Congress which will be held in St. Louis, October 3 to 8, 1904. The communication was ordered to be placed on file and the Secretary directed to express the appreciation of the Society for the courteous invitation.

In the absence of Mr. Hodgdon, the Secretary renewed the following motion, action on which was postponed at the last meeting:

Voted, That the Society indorse and recommend the changes in the Boston Building Laws proposed by the committee of the Society in its report made at the meeting held December 16, 1903; and that the same committee be instructed to take the necessary action to submit the proposed changes, with the indorsement of the Society, to the Mayor, and to appear in behalf of the Society, if in their opinion it is necessary, before the proper legislative committee in support of the proposed changes.

Professor Johnson moved to amend the report of the committee by striking out the figures "50" in the last line of the fourth paragraph of the portion of the report relating to concrete, and insert the figures "30," so that the sentence shall read: "Concrete shall not be strained in shear more than 30 pounds per square inch." The motion was duly seconded, and on a vote was declared adopted.

Mr. Leonard C. Wason offered several amendments to portions of the report relating to concrete, and after a short discussion, on motion of Mr. Manley, it was voted to refer the proposed amendments to the original committee for consideration and report.

It was also voted, on motion of Mr. Barnes, that when this meeting adjourns it be to next Saturday afternoon at 2 o'clock, in the Society's library.

The literary exercises were then taken up, and Mr. Leonard C. Wason gave an interesting talk on "Concrete-steel as Applied to Structural Work." The talk was fully illustrated by lantern slides.

Adjourned.

S. E. Tinkham, *Secretary*.

Boston, February 20, 1904.—An adjourned meeting of the Boston Society of Civil Engineers was held in the Society's library at 2 o'clock P.M.; Vice-President Frederick Brooks in the chair. Fourteen members present.

Mr. Cheney, for the Committee on Boston Building Laws, submitted a report in relation to amendments proposed by Mr. Wason. The committee suggested certain changes in the original report, so that it shall read as follows:

The Committee on Amendments to Boston Building Laws would recommend the following amendments to the present law:

Section 19. Immediately before table of "*Deflection.—Modulus of Elasticity*" insert the following:

Shearing and bearing stresses on bolts whether wrought iron or steel shall be not higher than allowed by the above table for wrought iron. All connections in skeleton buildings of which the height exceeds twice the least horizontal dimension, all joints in steel trusses and girders, and all connections of such trusses and girders to the sides of steel columns, shall be made by means of rivets.

Section 19. Amend paragraph beginning "Stresses for Steel," so that it will read:

Stresses for steel are those for "*Structural Steel,*" having an ultimate tensile strength of 55,000 to 65,000 pounds per square inch, an elastic limit of not less than one-half the ultimate strength and a minimum elongation in 8 inches of 1,400,000 divided by the ultimate strength, per cent.

Section 19. Amend the figure for the extreme fiber stress in cast iron in tension by increasing from *2500* to *3000*.

Section 19. In headings under both "*Stonework*" and "*Brickwork,*" after the word "Stresses," insert the words "*in compression.*"

Section 19. After the portion devoted to brickwork, insert the following:

Concrete.

When the structural use of concrete is proposed, a specification, stating the quality and proportion of materials and the method of mixing thereof, shall be submitted to the Building Commissioner, who may issue a permit at his discretion and under such further conditions as he sees fit to impose.

In first-class Portland cement concrete containing 1 part cement to not exceeding 6 parts properly graded aggregate of stone and sand, except in piers or columns of which the height exceeds 6 times the least dimension, the compressive stress shall not exceed 30 tons per square foot.

In piers and columns of first-class Portland cement concrete, containing 1 part cement to not exceeding 5 parts properly graded aggregate of stone and sand, where the height of pier or column is more than 6 times and does not exceed 12 times its least dimension, the compressive stress shall not exceed 25 tons per square foot.

In steel-concrete beams or slabs subjected to bending stresses, the entire tensile stress shall be carried by the steel, which shall not be strained above the limits allowed for this material. First-class Portland cement concrete in such beams or slabs, composed of 1 part cement to not exceeding 5 parts of properly graded aggregate of stone and sand, may be strained in compression to not exceeding 500 pounds per square inch. In case 1 part of cement to not exceeding 3 parts of properly graded aggregate of stone and sand is used, this stress may be increased to not exceeding 600 pounds per square inch. Concrete shall not be strained in shear more than 30 pounds per square inch.

Section 23. After "iron," where it first occurs, omit the words, "*or steel,*" and insert "*steel or concrete-steel,*" and after "masonry arches" insert "*or concrete-steel slabs.*"

Section 27. After "covers," in third line from end, insert "*or with first-class Portland cement concrete containing 1 part of cement to not exceeding 6 parts of properly graded aggregate of stone and sand, the concrete to be filled in and around the pile heads upon the intervening earth.*"

Section 30. In third line, after "nineteen," insert "*or Portland cement concrete as provided in Section 27.*"

Section 30. Between lines 15 and 16, after "foundations of brick," insert "*or concrete.*"

Section 55 to be amended to read as follows: All new or renewed floors shall be so constructed as to carry safely the weight to which the proposed use of the building will subject them, and every permit granted shall state for what purpose the

building is designed to be used; but the least capacity per superficial square foot, exclusive of materials, shall be:

For floors of dwellings and for apartment floors of apartment and public hotels, 50 pounds.

For office floors and for public rooms of apartment and public hotels, 100 pounds.

For floors of retail stores and public buildings, except schoolhouses, 125 pounds.

For floors of schoolhouses, other than floors of assembly rooms, 80 pounds, and for floors of assembly rooms, 125 pounds.

For floors of drill rooms, dance halls and riding schools, 200 pounds.

For floors of warehouses and mercantile buildings, at least 250 pounds.

The loads for floors not included in this classification shall be determined by the Commissioner, subject to appeal, as provided by law.

The full floor load specified in this section shall be included in proportioning all parts of buildings designed for dwellings, hotels, schoolhouses, warehouses, or for heavy mercantile and manufacturing purposes. In other buildings, however, certain reductions may be allowed, as follows: In girders carrying more than 100 square feet of floor, the live load may be reduced by 10 per cent. In columns, piers, walls and other parts carrying two floors, a reduction of 15 per cent. of the total live load may be made; where three floors are carried, the total live load may be reduced by 20 per cent.; four floors, 25 per cent.; five floors, 30 per cent.; six floors, 35 per cent.; seven floors, 40 per cent.; eight floors, 45 per cent.; nine or more floors, 50 per cent.

Your Committee would state that they have had the co-operation of the Committee on Building Law of Boston Society of Architects and the Building Commissioner of the City of Boston in the framing of the proposed amendments, and also their concurrence in the same.

Respectfully submitted,

John E. Cheney,
Joseph R. Worcester,
Henry A. Phillips.

After a lengthy discussion, it was voted to adopt the report in its amended form, 13 yes and 1 no.

It was further voted that the committee be authorized to appear before the Legislature and report the progress which the Society had made in the consideration of the matter of amending the Boston Building Laws.

Adjourned.

S. E. Tinkham, *Secretary*.

Sanitary Section.

Boston, Mass., February 3, 1904.—The first regular meeting of the Sanitary Section of the Boston Society of Civil Engineers was held at Hotel Nottingham, Boston, February 3, 1904. One hundred and twenty members and guests present.

The subject for discussion was "The Use of the Septic Tank in Sewage Disposal Works."

Papers were read by Frank A. Barbour, Boston; George E. Bolling, Brockton; H. P. Eddy, Worcester; X. H. Goodnough, Boston; H. W. Clark, Boston, and Prof. L. P. Kinnicutt, Worcester.

Communications were read by the Clerk from R. Winthrop Pratt, Columbus, Ohio, and Andrew J. Gavett, Plainfield, N. J.

The subject was discussed by C-E. A. Winslow, Massachusetts Institute of Technology; F. Herbert Snow, Boston; Dr. Douglas C. Moriarta, Saratoga, N. Y., and George A. Carpenter, Pawtucket, R. I.

William S. Johnson, *Clerk*.

Boston, Mass., March 2, 1904.—The first annual meeting of the Sanitary Section of the Boston Society of Civil Engineers was held at the United

States Hotel, Boston, March 2, 1904. Eighty-eight members and guests present.

Voted that the reading of the records of the last meeting be omitted.

The report of the Executive Committee was read and accepted.

The names of sixteen applicants for admission into the Section were presented. These applications having been favorably acted upon by the Executive Committee of the Section and the Board of Government of the Society, the Secretary was instructed to cast one ballot for each of the candidates, and they were declared elected to membership in the Section.

The following is a list of the men so elected: Henry J. Glendenning, William W. Burnham, F. G. Berry, Douglas C. Moriarta, M.D., Henry E. Mead, Adolph Getman, E. J. Winn, Theodore L. Pike, William H. Patterson, Patrick E. Pettee, Stephen De M. Gage, George E. Bolling, Earle B. Phelps, W. F. Whitman, George A. Smith and Charles W. Conant.

Voted that a committee of five be appointed by the Chair to retire and bring in nominations for officers for the ensuing year. The Chair appointed C. W. Sherman, J. A. Holmes, A. D. Fuller, C. R. Felton and T. Howard Barnes.

The committee brought in the following nominations:

For Chairman—Lewis M. Hastings.

For Vice-Chairman—Harrison P. Eddy.

For Clerk—William S. Johnson.

For Members of the Executive Committee—Freeman C. Coffin, Leonard Metcalf and George A. Carpenter.

By vote of the Section the Clerk cast one ballot for each of the above, and they were declared elected.

On motion of Bertram Brewer, it was voted that a committee of five be appointed by the Chair to consider the subject of "Uniform Statistics of Sewer Maintenance."

The Chairman appointed the following to serve on the committee: Bertram Brewer, Iriving T. Farnham, W. D. Hunter, W. D. Hubbard and H. P. Eddy.

The subject for discussion at the meeting was "The Cleaning and Flushing of Sewers," and it was participated in by J. L. Woodfall, W. D. Hubbard, Charles R. Felton, Dana P. Libbey, Bertram Brewer, W. C. Parmley, E. S. Dorr and F. H. Snow.

William S. Johnson, *Clerk.*

Report of the Executive Committee of the Sanitary Section of the Boston Society of Civil Engineers.

Boston, March 2, 1904.

The amendment of the By-laws of the Boston Society of Civil Engineers, providing for the formation of sections for the consideration of special branches of engineering, was adopted by the Society at a meeting held December 16, 1903. On the same date a petition, signed by fourteen members of the Society, was presented to the Board of Government for the formation, under the revised By-laws, of a section for the consideration of special subjects relating to sanitary engineering, to be known as the "Sanitary Section of the Boston Society of Civil Engineers." On December 21, 1903, the Sanitary Section was established by the Board of Government in accordance with this petition and under the authority of Section 15 of the By-laws.

Business meetings of the Section thus established were held January 1 and 27, 1904, at which meetings By-laws for the government of the Section were considered and adopted subject to the approval of the Board of Government. The By-laws finally adopted by the Section were approved by the Board of Government on January 27th, and are to be printed in a forthcoming number of the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

At the meeting of January 27th officers were elected to serve until the annual meeting, to be held in March.

The first general meeting of the Section was held February 3, 1904, at Hotel Nottingham, the meeting being preceded by a dinner. To this meeting and dinner a general invitation was extended to all those who were interested in the objects of the Section or in the subject discussed. Dinner was served to 74, and 120 were present at the meeting which followed the dinner.

The subject of the meeting was "The Use of the Septic Tank in Connection with Sewage Disposal Works," and papers were presented by Frank A. Barbour, C.E., of Boston; George E. Bolling, Chemist in charge of Sewage Disposal Works at Brockton; Harrison P. Eddy, Superintendent of Sewers, Worcester; R. W. Pratt, Engineer of State Board of Health, of Ohio; Andrew J. Gavett, City Surveyor of Plainfield, N. J.; X. H. Goodnough, Chief Engineer, State Board of Health of Massachusetts; Douglas C. Moriarta, M.D., Chairman of Sewer Commissioners, Saratoga, N. Y.; George A. Carpenter, City Engineer, Pawtucket, R. I.; H. W. Clark, Chemist of the State Board of Health of Massachusetts; Prof. L. P. Kinnicutt, of the Worcester Polytechnic Institute; C-E. A. Winslow, of the Massachusetts Institute of Technology, and F. Herbert Snow, C.E., of Boston. The papers which were presented at this meeting are to be printed in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

At the first two meetings of the Section the membership consisted of the fourteen signers of the petition to the Board of Government for the establishment of the Section. Previous to the February meeting an opportunity was given to members of the Boston Society of Civil Engineers to make application for enrollment in the Sanitary Section, and such applications have been received from 100 members and one associate of the Society, making a total membership in the Section of 115, or about 22 per cent. of the total membership of the Society.

Applications have been received from sixteen persons, not members of the Boston Society of Civil Engineers, for Section membership. These applications have been favorably acted upon by the Executive Committee of the Section and the Board of Government of the main Society, and will be presented to the Section at the March meeting.

Respectfully submitted for the Executive Committee,
WILLIAM S. JOHNSON, *Clerk.*

TWENTY-SECOND ANNUAL DINNER.

The twenty-second annual dinner of the Boston Society of Civil Engineers was held at the Hotel Brunswick, Boston, Tuesday evening, March 1, 1904, and was attended by 151 members and guests. An informal reception was held at 6 and the dinner was served at 7 o'clock.

At the after-dinner speaking, the President of the Society, Prof. Ira N. Hollis, acted as toastmaster, and in opening called attention to the change

in the Constitution of the Society which permitted the formation of sections. The Sanitary Section had been organized with a large membership, and he hoped others would soon be formed. He described the true function of a local society of engineers as one which would bring together members of the national societies residing in that district, and expressed the hope that the different engineering societies in Boston would co-operate and form one large local society.

The first speaker introduced was the Hon. James F. Jackson, Chairman of the Massachusetts Railroad Commissioners, who spoke of the deep obligation the Commission was under to the civil engineering profession, upon which it has depended very much. He referred to the difference in railroad managements, where on one road attention is given to the convenience and comfort of the traveling public, while on another the employers are indifferent. This is caused mainly by the disadvantage of corporate organization where the officials never reach the men and by the failure to separate the administrative power and the question of expenditure of money. Mr. John Ritchie, President of the Appalachian Mountain Club, expressed the best wishes and compliments of that Club and his appreciation of the organization of the Boston Society of Civil Engineers and the excellent work it is doing. Prof. A. E. Kinnelly of Harvard University, responded for the electrical engineers, and expressed the desire that the branch of the American Institute of Electrical Engineers in Boston should be more closely connected with the different branches of engineering, for thereby they would gain knowledge of what was being done by engineers of all specialties. Mr. L. M. Hastings, Chairman of the newly-formed Sanitary Section, described the work which that Section hoped to accomplish. Mr. Walter C. Parmley, President of the Civil Engineers' Club of Cleveland, brought the fraternal greeting of that Club, and Capt. W. E. McKay, President of the New England Association of Gas Engineers, closed the speaking of the evening.

Among the guests of the Society, in addition to the speakers already mentioned, were: Gen. S. M. Mansfield, late Chief of Engineers, United States Army; Mr. E. C. Brooks, President New England Water Works Association; Capt. Geo. H. Kearney, United States Navy, and Mr. A. W. Parker. Music was furnished by the Apollo Quartette of Boston.

Boston, March 16, 1904.—The annual meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.40 o'clock P.M.; President Ira N. Hollis in the chair. Eighty-six members and visitors present.

The records of the last regular meeting and of the adjourned meeting of February 20, 1904, were read and approved.

The following were elected to membership: Edward G. Bradbury, Albert F. Brown, George A. Clark, Harry W. Clark, Luzerne S. Cowles, Fred B. Forbes, Andrew J. Gavett, Wilberforce B. Hammond, Herbert C. Hartwell, Paul Hansen, William H. Jaques, Edwin R. Olin, John J. Phelan, Herbert W. Sheldon, Frederick E. Tupper, Charles U. Umstead, John J. Van Valkenburg, Ralph Whitman, Rufus M. Whittet and Charles-Edward Amory Winslow.

The question of adopting, at a second meeting, the report of the Com-

mittee on Amendments to Boston Building Laws was then taken up. After a short discussion by Messrs. Main, Cheney and Worcester, and a very exhaustive one in opposition by Mr. Howland, the report was adopted for the second time, as required by the Constitution, 36 voting in favor and 3 against.

The President read the annual report of the Board of Government, which was accepted and ordered to be placed on file.

The Treasurer read his annual report, which was accepted and ordered to be placed on file.

The Secretary read his annual report, which was also accepted and ordered to be placed on file.

Mr. Miner, for the Committee on Excursions, read the annual report of that committee, which was accepted and placed on file.

The Librarian read the annual report of the Committee on the Library, which was accepted and placed on file.

Mr. Howe made verbal reports for the Committees on Quarters and on Advertisements.

It was voted to appropriate the sum of $50 for the purchase of standard engineering books for the Library.

It was voted to refer to the Board of Government, with full powers, the appointment of the special committees of the Society and the selection of the members thereof.

It was voted to refer to the Board of Government, with full powers, the question of exchanging club house and library privileges with other engineering societies and the issuing of cards of identification.

It was also voted to refer to the Board of Government the question of entertaining the British Mechanical Engineers who are to visit Boston this summer, and the Board was also authorized to confer with a committee of the mechanical engineers of Boston, in relation to the matter.

On motion of Mr. Miner, the thanks of the Society were voted to Rear-Admiral Mortimer C. Johnson, Commandant, and to Charles W. Parks, Civil Engineer at the Navy Yard, for courtesies extended to the Society on the occasion of the visit to the Charlestown Navy Yard this afternoon.

Messrs. Austin B. Fletcher and W. Lewis Clark, the tellers of election, submitted the result of the letter ballot for officers, and in accordance with their report, the following officers were declared elected:

President—Frederick Brooks.

Vice-President (for two years)—Otis F. Clapp.

Secretary—S. Everett Tinkham.

Treasurer—Edward W. Howe.

Librarian—Frank P. McKibben.

Director (for two years)—Leonard Metcalf.

The President-elect was then presented, and in a few pleasant words thanked the Society for the honor conferred upon him.

President Hollis then addressed the meeting in a very interesting manner, taking for his subject "Some Data on Marine Engines."

Adjourned.

S. E. TINKHAM, *Secretary.*

Annual Report of the Board of Government for the Year 1903-04.

Boston, March 16, 1904.

To the Members of the Boston Society of Civil Engineers:

In compliance with the requirements of the Constitution, the Board of Government submits its report for the year ending March 16, 1904.

At the last annual meeting the total membership of the Society was 509, of whom 502 were members, 2 honorary members and 5 associates. During the year we have lost 14 members: 5 by resignation, 4 by forfeiture of membership for non-payment of dues and 5 by death. There have been added to the Society during the year 33 members, of whom 30 are new members, 3 are members reinstated by the Board of Government and 1 has been transferred from temporary membership to permanent membership. Our present membership consists of 2 honorary members, 8 associates and 518 members, a total of 528. Two additional members have been elected, but have not yet completed their membership. Sixteen new members have been elected in the Sanitary Section, of whom 4 have completed their membership at this date. The record of deaths during the year is:

George R. Hardy, died April 2, 1903.

Alphonse Fteley, died June 11, 1903.

William C. Ogden, died October 12, 1903.

Frank P. Johnson, died November 1, 1903.

George A. Ellis, died December 27, 1903.

Ten regular and two special meetings have been held during the year, and the twenty-second annual dinner was given at the Hotel Brunswick, on March 1, 1904. The average attendance at the regular and special meetings was 81; the largest attendance was 130, and the smallest 35. The number at the annual dinner was 151.

At the several meetings the following papers have been read:

March 18, 1903.—Mr. A. W. Parker, "Early and Curious Types of the Cantilever Bridge in New England." (Illustrated.) Discussion.

Address of President George A. Kimball.

April 15, 1903.—Memoir of George R. Hardy.

May 20, 1903.—Dr. Louis Duncan, "The Electrical Transmission of Power."

June 24, 1903.—John R. Freeman, "Problems Connected with the Proposed Charles River Dam." (Illustrated.)

September 16, 1903.—William O. Webber, "Rainfall and Run-off of New England and Atlantic Coast Streams." Discussion. (Illustrated.)

October 21, 1903.—President Ira N. Hollis, "Description of Concrete Stadium for Harvard College."

December 8, 1903.—Prof. L. J. Johnson, "Prominent Features in the Design of the Steel-Concrete Work of the Harvard Stadium." (Illustrated.) Discussion by Professors Norton and Lanza of the Institute of Technology and Professor French of the Worcester Polytechnic Institute.

December 16, 1903.—Memoir of Alphonse Fteley.

January 14, 1904.—George B. Francis, "Timber Crib Foundations." (Illustrated), and "Description of the Construction of a Double-track Third-rail Electric Road Between Scranton and Wilkesbarre." (Illustrated.)

January 29, 1904.—George A. Kimball, "Notes on Passenger Traffic in Some Foreign Cities." (Illustrated.)

February 17, 1904.—Leonard C. Wason, "Concrete-Steel as Applied to Structural Work." (Illustrated.)

On account of the number of special meetings of the Society and the meetings of the Sanitary Section, the only informal meeting held during the year was on April 1, 1903, at which a discussion was held on the best method of making tight joints in pipe sewers, Mr. E. W. Branch speaking particularly on experiments made with asphalt joints.

During the year the Constitution and By-laws of the Society have been amended as follows: (1) In relation to dues. Those now joining the Society pay no dues during the first year, their initiation fee being considered sufficient to entitle them to membership for one year. (2) A salary of $50 has been voted for the services of the Librarian. (3) Section 15 has been changed to provide for Sections of the Society. The charges for those members of the Sections who are not members of the Society are $5 entrance fee and $5 annual dues.

The modification of Section 15 marks a change in the organization of the Society in the direction of recognizing specialization in engineering. This change was foreshadowed by allowing the use of the library to two New England societies, namely, the New England Waterworks Association and the Gas Engineers. It seems to proceed upon the theory that the Boston Society of Civil Engineers should be the general society of this community, and that the societies built up upon specialties should be branches thereof.

One Section was established, to be called the Sanitary Section of the Boston Society of Civil Engineers, by petition of fourteen members of the Society presented to the Board of Government on December 16, 1903. This Section was authorized by the Board of Government on December 21st, and the By-laws finally adopted were approved by the Board of Government on January 27th. Officers have been elected, and the first general meeting of the Section was held on February 3, 1904, at the Hotel Nottingham. The Section now numbers 114 members and 1 associate of the Boston Society of Civil Engineers and 4 members who are not members of the Boston Society of Civil Engineers. Thus the total membership is 119. Two papers have been read at meetings of the Section: (1) "The Use of the Septic Tank in Connection with Sewage Disposal Work." (2) "The Cleaning and Flushing of Sewers."

There has been some discussion among the mechanical engineers of this neighborhood as to the advisability of establishing another section of the Boston Society of Civil Engineers. A committee was appointed to consider the subject and various meetings were held. At a meeting of mechanical engineers on February 25th, it was voted to recommend that the mechanical engineers in New England become members of the Boston Society of Civil Engineers. The committee appointed to consider the subject had been unanimously of the opinion that the mechanical engineers should not organize themselves into a local society separate from civil, electrical and other engineers, the reasons given being as follows: (1) The Society is of long standing as an existing organization, and is in a flourishing condition. (2) It has its own library, immediately available for the use of those joining the Society. (3) It has a well-established and high-grade journal for the publication of papers presented at its meetings. (4) Its membership includes already between 500 and 600 engineers belonging to all branches of the profession. It is hoped that this discussion by the mechanical engineers may result in a large increase of membership in our Society.

A committee of the Society, consisting of three members, was appointed in the late fall to consider the Boston building laws, and to suggest to the Legislature such modifications as seemed advisable. This committee has appeared at several hearings, and its report has been considered by the Society, although it is not yet approved. The discussion of the work of the committee has given rise to some further consideration of the policy for the future. Is it good policy for the Society to make recommendations in regard to legislative enactments, especially where the recommendations involve a large amount of professional experience? Where the subject is one involving the welfare of the community, such as the better construction of buildings, it has seemed to the Board of Government entirely proper for the Society to appear and to assist the State by its advice.

The income of the Society during the year has just met its expenses. Nevertheless, the Board of Government has adopted the recommendation of previous Boards with regard to the purchase of engineering books to be placed in the library. The sum of $50 was voted for this purpose, and it is earnestly recommended that the practice be continued.

A badge of the Society was adopted during the fall, and 125 of the members have purchased them.

During the spring of 1903 the Board of Government voted to allow the New England Association of Gas Engineers a bookcase and library privileges in the Society rooms.

It has been suggested, in accordance with the practice of other engineering societies, that arrangements be made for an exchange of club house and library privileges with the several national and local engineering societies. By means of a card of identification issued to its members, this Society would thus have open to it the rooms of societies in a number of cities. The Board of Government recommends this to the consideration of the Society.

For the Board of Government,
IRA N. HOLLIS, *President.*

ABSTRACT OF THE TREASURER'S AND THE SECRETARY'S REPORTS FOR THE YEAR 1903-04.

CURRENT FUND.

Receipts:

Dues from new members	$137.00	
Dues for year 1898-99	8.00	
Dues for year 1903-04	3,354.00	
Dues for year 1904-05	31.00	
Sales of JOURNALS and library fines	9.21	
Rent of rooms	933.33	
Advertisements in JOURNAL	448.20	
Interest on deposits	18.56	
Balance on hand March 19, 1903	520.07	
		$5,459.37

Expenditures:

Rent	$1,685.00	
Association of Engineering Societies	1,037.30	
Printing, postage and stationery	625.85	

Salary of Secretary	$400.00	
Furniture	171.40	
Library maintenance	143.46	
Incidentals	137.01	
Commission on advertisements	134.70	
Salary of Custodian	100.00	
Annual dinner	90.50	
Stereopticon	60.00	
Periodicals	53.30	
Books	48.70	
Binding	48.25	
Lighting rooms	42.42	
Reporting meetings	39.00	
Salary of Librarian	16.66	
Sample badges	15.00	
		$4,848.55

Balance on hand March 16, 1904	$610.82
Due from Permanent Fund	169.43
Cash balance March 16, 1904	$441.39

PERMANENT FUND.

Receipts:

Thirty-one entrance fees, Society	$310.00	
Four entrance fees, Sanitary Section	20.00	
Interest on deposits, Savings Banks	242.64	
Subscription to Building Fund	100.00	
Interest on bond	36.00	
Balance on hand March 19, 1903	264.57	
		$973.21

Expenditures:

Dues on shares Merchants' Co-operative Bank	$300.00	
Dues on shares Volunteer Co-operative Bank	300.00	
Dues on shares Workingmen's Co-operative Bank	300.00	
Deposit in Provident Institution for Savings	44.55	
Deposit in Boston Five-cents Savings Bank	41.55	
Deposit in Warren Institution for Savings	39.35	
Deposit in Franklin Savings Bank	38.49	
Deposit in Eliot Five-cents Savings Bank	39.85	
Deposit in Institution for Savings in Roxbury	38.85	
		$1,142.64

Due Current Fund	$169.43

PROPERTY BELONGING TO THE PERMANENT FUND, MARCH 16, 1904.

25 shares Volunteer Co-operative Bank	$3,272.50
25 shares Workingmen's Co-operative Bank	2,932.48
25 shares Merchants' Co-operative Bank	2,327.12
Deposit in Provident Institution for Savings	1,306.83
Deposit in Boston Five-cents Savings Bank	1,218.83

Deposit in Eliot Five-cents Savings Bank	$1,168.92
Deposit in Warren Institution for Savings	1,153.95
Deposit in Institution for Savings in Roxbury	1,140.27
Deposit in Franklin Savings Bank	1,129.07
One Republican Valley Railroad bond (par value)	600.00
	$16,249.97
Less amount due Current Fund	169.43
	$16,080.54
Amount as per last annual report	14,998.74
Increase during the year	$1,081.80

TOTAL PROPERTY OF THE SOCIETY IN THE POSSESSION OF THE TREASURER.

Permanent Fund	$16,249.97
Current Fund	441.39
	$16,691.36
Amount as per last annual report	15,518.81
Total increase during the year	$1,172.55

Report of Committee on Excursions.

Boston, March 16, 1904.

To the Members of the Boston Society of Civil Engineers:

The Committee on Excursions herewith presents its annual report for the year 1903-04:

Twelve excursions have been made during the year, as follows:

May 20, 1903.—To the State Street Section of the East Boston Tunnel. Attendance, 35.

June 17, 1903.—An all-day excursion to Providence, R. I. The State House and the State Normal School were visited, and at Field's Point the Chemical Precipitation Works were inspected, and a Rhode Island shore dinner was provided for the party. On the return trip a stop was made at Fall River, and the grade-crossing work there was inspected. Attendance, 44.

July 25, 1903.—To the pumping station, reservoir and dam of the Lynn Waterworks at Lynn Woods. Attendance, 40.

August 22, 1903.—A harbor excursion to Boston Light and to the Graves Light now building. Attendance, 111.

September 16, 1903.—To the East Boston Tunnel. The party entering the tunnel at Maverick Square and walking through to the Old State House. Attendance, 75.

October 17, 1903.—To the Stadium of Harvard University. A concrete-steel structure at Soldiers' Field, Brighton. A heavy rain shower interfered with this excursion. Attendance, 35.

October 31, 1903.—To the Stadium at Soldiers' Field. After the struc-

ture had been inspected, the Harvard-Carlisle foot-ball game was witnessed from the top of the Stadium. Attendance, 90.

November 7, 1903.—To the concrete-covered reservoir of the Brookline Waterworks at Wabon Hill. Attendance, 19.

January 14, 1904.—To the United Shoe Machinery Company's buildings of concrete construction, at Beverly, Mass. Attendance, 47.

January 27, 1904.—To the new buildings of the B. F. Sturtevant Company at Readville, and to the power house of the N. Y., N. H. and H. R. R. Co. at Hyde Park. Attendance, 28.

February 17, 1904.—To the extension of the Commissioners' Channel of Stony Brook through the Back Bay Fens, Boston. Attendance, 19.

March 16, 1904.—To the Charlestown Navy Yard. Under the guidance of the civil engineer of the yard, the coal pockets, dry dock, machine shop, boat house and cordage works were visited. The cruiser "Des Moines" was visited and the machinery was shown by the officers of the vessel. Attendance, 79.

Total attendance, 622. Average 51.8.

Six numbers of the *Bulletin of Engineering Work* have been published during the year.

The Treasurer has a cash balance of $25.05 and 30 coupon railroad tickets to Beverly. The committee expect that their successors will find these tickets useful.

Respectfully submitted,

HERMAN K. HIGGINS, *Chairman*,
FRANKLIN M. MINER, *Sec'y and Treas.*
EDWARD P. ADAMS,
W. LEWIS CLARK,
GEORGE A. KING,
Committee on Excursions.

REPORT OF THE COMMITTEE ON THE LIBRARY.

BOSTON, March 16, 1904.

To the Members of the Boston Society of Civil Engineers:

The Committee on the Library begs leave to make the following report for 1903-04:

As indicated in the report of last year, it has become necessary to increase the shelf room of the library to take care of the large number of books and pamphlets received. This shelf room has been gained by the addition of cases, in which have been placed all of the reference books, which comprises Section 10. The addition of these cases has necessitated the removal of the long table which formerly held the periodicals. The periodicals have been placed in a case made especially for the purpose. During the coming year if the number of books received in the library is as large as during the past year more shelf room will be needed. This can be obtained either by adding more bookcases or by increasing the size of the quarters.

There has been received since the last annual meeting 309 bound volumes, which is approximately 25 per cent. more than has been received in any year since 1897. Of these bound volumes 16 have been purchased

and the remainder are largely reports which have been presented to the Society. In addition to the above bound volumes received and accessioned, 2000 pamphlets—mostly municipal reports—have been received and filed away. The committee wishes to thank the members who have contributed books or pamphlets, and wishes to call attention to the recent circular asking for various reports.

Fines to the amount of $4.46 have been collected and paid to the Treasurer.

The committee wishes to recommend that the practice of purchasing standard engineering books for the library be continued for the coming year.

Respectfully submitted,

Frank P. McKibben,
Kilburn S. Sweet,
Frederic I. Winslow,
John N. Ferguson,
L. J. Johnson,
Committee on the Library.

Engineers' Club of Minneapolis.

173d Meeting, Minneapolis, Minn., February 27, 1904.—The meeting was called to order by Vice-President Burch. The minutes of the last meeting were read and approved. The following names were proposed for membership:

J. J. Flather, Professor of Mechanical Engineering, University of Minnesota.

D. H. Keesling, machinist, 229 Twentieth Avenue, S.

Mr. Tate, Chairman of the Louisiana Purchase Exposition Exhibit, reported progress, showing that a very creditable exhibit was being made ready.

Mr. W. W. Redfield, of the committee appointed to prepare resolutions upon the death of Mr. Van Duzee, reported that a member of the Club who was well acquainted with the deceased was now at work upon an article descriptive of his life and work, to be published in the Journal.

Mr. Francis Henry, associate member of the American Society of Civil Engineers, delivered a paper on "Rice Culture in Texas and Louisiana." A short discussion followed.

Prof. Frederick H. Bass, of the University of Minnesota, read a paper on "The Relation of the Engineer to the Public Health." Mr. Bass' paper had special reference to the present epidemic of typhoid fever on the East Side. He showed, beyond a doubt, that the cause of the epidemic was due to the opening of the East Side pumping station, which is situated below Nicollet Island, where a number of sewers empty into the river. Discussion followed by Messrs. Fanning, Hoag, Pardee, Dr. Hall and others.

A resolution was introduced by Professor Hoag, as follows: That both the East and West Side lower pumping stations should be closed and kept closed, as an epidemic of typhoid fever had always followed the opening of these stations.

An amendment was offered by Professor Bass and accepted by Professor

Hoag that these stations might be used in case of fire. The resolution in its modified form was unanimously passed.

The meeting then adjourned.

J. B. GILMAN, *Secretary.*

Engineers' Club of St. Louis.

576TH MEETING, ST. LOUIS, MO., MARCH 2, 1904.—The meeting was held at the Club Rooms, 709 Pine Street, Wednesday evening, March 2d. President Ockerson presided. There were present twenty-seven members and three guests.

The minutes of the 575th meeting were read and approved, and the minutes of the 363d meeting of the Executive Committee were read.

The application for membership of Mr. Arthur A. Bonsack was presented.

Mr. K. H. Jacobsen was elected to membership.

Mr. Robert Moore read a portion of a letter outlining the proposed trips of the French engineers and the dates of their visits to the Exposition.

The memoir upon the death of Prof. J. B. Johnson, prepared by Edward Flad, W. H. Bryan and J. M. Chaphe, was read by Mr. Bryan and advised spread on the records of the Club.

Mr. S. B. Russell, Chairman of the World's Fair Committee, made a brief report of progress, and asked for a special meeting of the Club, to consider matters relating to material for the proposed souvenir.

On motion of Mr. Pfeifer, the special meeting was ordered for Friday evening, March 11th, at 8 o'clock.

The paper of the evening, by Dr. A. L. McRae, on "A Study of Lord Kelvin's Suggestion for a Heating Plant," was presented. Dr. McRae brought out the idea of the suggestion as one for the use of waste products—such as exhaust steam, water used for cooling purposes in compressor plants, etc. Lord Kelvin suggested a warming system which should be the reverse of a refrigerating plant, *i. e.*, in Lord Kelvin's system heat would be the direct produce and refrigeration the waste. Owing to the relatively low temperatures of the warming materials a large radiating surface would be required. Such a system is not at present practicable, but may be made so.

After discussion by Messrs. Wall, Humphrey, Robert Moore, Russell and Langsdorf, the meeting adjourned.

R. H. FERNALD, *Secretary.*

577TH MEETING, ST. LOUIS, MO., MARCH 11, 1904.—A special meeting was held at the Club Rooms, 709 Pine Street, Friday evening, March 11th.

The regular order of business was set aside and the evening devoted to details connected with the publication of the proposed "World's Fair Souvenir" now being prepared by the Club.

Vice-President Moore presided. Twenty-two members were present. Much interest was taken in the special work of the evening.

R. H. FERNALD, *Secretary.*

Association of Engineering Societies.

Vol. XXXII. APRIL, 1904. No. 4.

PROCEEDINGS.

Civil Engineers' Club of Cleveland.

Report of Committee on bill of Senator Harvey, relative to lake and stream pollution.

Cleveland, Ohio, March 2, 1904.

To the President and Members of the Civil Engineers' Club of Cleveland.

Gentlemen:—At the last meeting of this Club a resolution was adopted directing the appointment of a committee to investigate the action proposed by Senator M. W. Harvey, of this district, relative to the prevention of the pollution of the waters of Lake Erie. The undersigned, members of this committee duly appointed, met in this city, pursuant to the call of the chairman of the committee, on Saturday, February 27, 1904, and gave to the subject such consideration as was practicable, and now have the honor to submit the following report:

"The object of the Bill in question, as therein stated, is to provide for the appointment of 'a commission to investigate the pollution of the waters of Lake Erie and of the rivers and streams of Ohio from which the water supplies of cities and villages is obtained.' To effect this result it is proposed to authorize by law the Governor of the State to appoint 'a commission of three members who are citizens of Ohio, to confer with the Board of Health and the federal authorities, and to investigate and report at the earliest possible date, not later than November 15, 1905, a remedy or remedies which, in their judgment, will decrease, abate or prevent such pollution.'

"It is the opinion of your committee that the information thus sought to be obtained would be of great value and utility to the State of Ohio; and further that the means proposed in the Bill under favorable conditions are adequate to procure the information sought. A commission of three members is large enough for the purpose, but the success or failure of their investigations will depend very largely upon the individual fitness of the members for the work confided to them. They should each be a specialist in some particular department of the subject under investigation, and should be specially educated and trained for work of this character. It is too much to expect that an ordinary citizen, who has given no special thought to and has received no special training for this work, would be able or willing to prepare himself to carry out such an investigation.

"It would seem proper that the commission should contain one civil engineer of experience and mature judgment, who has given special study and investigation to questions of rainfall, surface drainage and the flow of water in rivers and streams. Another member should be a sanitary engineer of wide experience, who has knowledge of the practical methods of town and city drainage and the various ways of disposing of sewage. The third member might well be a lawyer acquainted with the legislation that has been had in other States, and able to determine it's value or suitability for the State of Ohio, and to express the result of the finding of the Board in a form to be incorporated in the laws of the State. The Board ought, therefore, to be composed of professional men, men who gain their livelihood by the very kind of work which the State invites them to perform.

"Section 2 of the Bill provides that this commission shall serve without compensation. In other words, it asks these members to tax themselves a number of days' labor for the welfare of the State. This form of taxation is not equitable and is not likely to lead to the best results. The works of unpaid commission are generally worth about what they cost, and the State would do well to adopt the method followed by private individuals or corporations and to offer to pay the market rate for whatever commodity or service it desires. It is suggested, therefore, in criticism of the proposed Bill, that this unpaid commission is a mistake. The compensation need not be very large and ought not to be large enough to induce any one to intrigue for an appointment to serve upon the commission; but there should be a provision, not only for the actual expenses of the commissioners, but also for a moderate per diem compensation for the actual time they may give to the work. This compensation might be $10 or $15 a day, and if it were thought best, the total amount which any commissioner could receive might be limited in the act to $200 or $300. The amount of money appropriated by the act should be increased accordingly. In the selection of men for appointment, it would be an advantage to obtain them from places not too remote, in order that frequent meetings might be had for the purpose of discussion at a small cost for traveling expenses and a minimum loss of time for the members.

"The State of Ohio is bounded on the north by Lake Erie and on the south by the Ohio River. The rivers of the State are, therefore, short and small. The density of the population and the numerous large towns which are being built up threaten a rapid and dangerous pollution of the ordinary sources of water supply for the inhabitants. There can be no question that this is a matter of grave importance. It is too widespread in its cause and effect to be dealt with by individuals or small communities, and in some respects it is even beyond the power of the State; but a beginning should be made, and such information as can be gathered from the experience of older States and countries should be collected and digested, to the end that when action is taken the proved and well-known errors and mistakes may be recognized and avoided."

Respectfully submitted,

(Signed) Dan C. Kingman, *Major Engineers, U. S. A.*,
James Ritchie,
Robert Hoffman.

CLEVELAND, MARCH 8, 1904.—The regular meeting of the Civil Engineers' Club of Cleveland was held Tuesday, March 8th, at 8.30 P.M. In the absence of the President and Vice-President the Secretary was elected temporary Chairman.

The following officers were elected for the ensuing year:

For President—Alexander E. Brown.

For Vice-President—Dr. Dayton C. Miller.

For Secretary—Joseph C. Beardsley.

For Treasurer—Robert Hoffman.

For Librarian—Charles O. Palmer.

For Directors—Walter M. Allen and Harry S. Nelson.

The Tellers also reported the adoption of the following amendments to the Constitution:

BALLOT FOR CONSTITUTIONAL AMENDMENTS.

Vote closes March 8th, at 8 o'clock P.M.

SECTION III, ARTICLE 4.

At the end of said Section III, add the following: "Except in case of the resignation of an Active Member whose long and efficient service in the Club, in the judgment of the Executive Board, deserves special recognition and acknowledgment. In such case said Board may, at its discretion, ask such member to withdraw his resignation, and, if this request be complied with, shall cause his name to be transferred to the Retired List of Active Members, which is hereby authorized. He shall thereafter be exempt from all fees and dues of the Club, but shall be entitled to all the rights and privileges heretofore enjoyed as an Active Member, except the right to vote and hold office. Such membership shall not include the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, except upon payment of its actual cost to the Club, by such member. The Secretary shall serve written notice on such person of his transfer of membership, as per form B B in the Appendix."

SECTION VII, ARTICLE 6.

The third sentence to be stricken out and the following inserted in lieu thereof: "The Permanent Fund shall not be expended for any purpose except on the unanimous vote of the Executive Board, confirmed by letter-ballot of the Club, in which two-thirds the legal ballots cast shall be in favor of such expenditure."

The eighth sentence to be stricken out and the following inserted in lieu thereof: "No money shall be transferred from one fund to another unless so ordered by unanimous vote of the Executive Board, confirmed by letter-baliot of the Club, in which two-thirds of the legal ballots cast shall be in favor of such transfer."

The reports of the Secretary, Treasurer, Librarian and Program Committee were read and adopted and ordered placed on file. The report of Major Dan C. Kingman, Corps of Engineers, U. S. A., Chairman of a Committee on a bill introduced in the Ohio Legislature by Senator M. W. Harvey, was read. This report (see pages 41 and 42) was adopted by the Club and ordered placed on file. The President's Annual Address, on "The Intercepting Sewer System of Cleveland," was read by the Secretary, and the meeting then adjourned.

JOE C. BEARDSLEY, *Secretary.*

Technical Society of the Pacific Coast.

San Francisco, Cal., February 26, 1904.—A meeting of the Board of Directors was held at the residence of the Secretary, Mr. Otto von Geldern, who had invited the gentlemen of the Board to dinner.

Present: Directors Dickie, Grunsky, Riffle, Connick, Schild, Lietz, Uhlig and von Geldern.

In the discussion of the subject of the coming spring meeting, the following details were agreed upon:

That the meeting begin on the evening of the last Thursday in May, and that it be continued during the following Friday and Saturday.

The program to be outlined as follows:

First evening (Thursday)—Introduction of members and the address of the President.

Second day (Friday)—Morning devoted to visiting points of interest in the vicinity.

Afternoon—Reading two or three of the contributed papers.

Evening—Devoted to the reading and discussion of technical papers.

Third day (Saturday)—Morning, visiting or as may be arranged by the committee.

Afternoon—Reading of technical papers.

Evening—Banquet.

The following contributions have been promised:

1. Prof. C. D. Marx. Subject: "Consideration of Uplift as Affecting the Design of Masonry Dams."
2. John Richards. Subject: "Steam Turbine Motors," illustrated by diagrams.
3. Marsden Manson. Subject: "The Reclamation of a Mountain Swamp."
4. Franklin Riffle. Subject: "Pipe Joints for High Pressures."
5. Prof. F. G. Hesse. Subject: "Jet Pumps—New and Original Developments."
6. C. E. Grunsky. Subject: "The Water Supply of San Francisco."
7. M. C. Couchot. Subject: "Armored Concrete Construction."
8. Prof. C. B. Wing. Subject: "Collection and Discussion of Material in County Highway Bridges."
9. J. J. Welsh. Subject: "Experiments in Driving Piles for a Foundation with a Steam Hammer."
10. C. J. Wheeler. Subject: "Manufacture of Portland Cement."
11. F. P. Medina. Subject: "The Laying of the Commercial Pacific Cable."
12. Loren E. Hunt. Subject: "Timber Tests, Laboratory Methods and Results."
13. H. I. Randall. Subject: "Vertical Railway Curves."

Meeting adjourned, to be called again by the President, and subsequently set for Friday, March 18, 1904.

Adjourned.

Otto von Geldern, *Secretary*.

San Francisco, Cal., March 18, 1904.—A meeting of the Board of Directors was held at the residence of the Treasurer, Mr. E. T. Schild, who had invited the gentlemen of the Board to dine with him.

Present: Directors Dickie, Uhlig, Lietz, Schild and von Geldern. For Director Grunsky, Past President E. J. Molera and for Director Le Conte Prof. C. B. Wing had been appointed to act.

It was ordered that the Secretary distribute return postal cards to all members to gather information as to how many will attend the spring meeting, and whether members will be accompanied by relatives or friends, in order to make provisions for them while in the city.

It was also agreed to send a program of the meeting to all members, including a list of the papers that have been presented to be read.

All papers should be in the hands of the Secretary by the end of April or beginning of May.

The following committees were appointed by the Chair:

Entertainment Committee—Messrs. Uhlig and Schild.

Excursion Committee—Messrs. Molera and von Geldern.

These committees will outline a detailed and definite plan, and may call upon other members to augment the committee, if the work to be done requires additional help.

Meeting adjourned to be called by the President.

Otto von Geldern, *Secretary.*

Montana Society of Engineers.

The regular meeting for March was held in the Society rooms, Tuttle Block, at the usual hour, March 12, 1904. On the arrival of a quorum, Mr. R. R. Vail was chosen Chairman *pro tem.* The minutes of the February meeting were read and approved. Applications for membership in the Society from Herbert McNulta, of Anaconda, Montana, and Carroll R. McCulloch, of Havre, Montana, were read, approved and the Secretary was instructed to send out ballots for these parties. Mr. Frank S. Mitchell was unanimously elected to membership in the Society. A communication from the Brooklyn Engineers' Club requesting the privileges of our Society rooms in case any of the Brooklyn engineers should visit this city was read and and the Secretary was instructed to grant the same and so answer the request. The Secretary read an invitation to the members of the Montana Society of Engineers to attend an International Engineering Congress, to be held at St. Louis, Mo., October 3 to 8, 1904, under the auspices of the American Society of Civil Engineers. The Montana engineers are invited to become members of the Congress, and to take part in its proceedings in person or by written communications.

A long list of subjects for discussion can be obtained for the members of this Society as soon as issued. The membership fee of the Congress is $5, entitling the member to all the publications of the Congress. All members of the American Society of Civil Engineers will be members of the International Congress and entitled to its publications without the above-named fee. There being no further business the meeting adjourned.

Clinton H. Moore, *Secretary.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., MARCH 14, 1904.—A regular meeting of the Civil Engineers' Society was called to order by President Starkey at 8.15 P.M. Present, twelve members and one visitor. Minutes of the previous meeting read and approved.

A communication from Charles Warren Hunt, Secretary, inclosing prospectus of the International Engineering Congress, was read and ordered acknowledged and filed.

The Secretary was instructed to reply favorably to the Brooklyn Engineers' Club as to exchange of courtesies.

The resignation of Mr. Tracy Lyon was accepted.

Mr. W. A. Truesdell informally presented some interesting facts and conjectures as to the origin of the United States system of land surveys. He has been unable to find, either at Washington or in the Ohio State records, any official reports of the earlier heads of the Government surveys. and very little definite information as to their individual efforts.

Who originated the present system of surveys? His researches have led him to decide that Washington, Harrison, Tiffin and Pease had little to do with the plan. Jefferson possibly may have been concerned in it. The germ of the scheme seems to have originated in 1764 with Thomas Hutchins, afterward the first official surveyor of the public lands (the United States Geographer). His successor, the first Surveyor-General, Rufus Putnam, apparently first suggested the six-mile township of thirty-six lots laid out in ranges.

The present system was established in 1785, and Hutchins surveyed the seven ranges in Eastern Ohio the following year. Putnam, his successor, continued the Ohio survey in 1796, his townships being groups of sections instead of lots, and numbered in the order of to-day. The military bounty lands were laid out in townships five miles square in 1796.

Jefferson deposed Putnam, after six years' service, for accepting careless work, and Jared Mansfield, a careful and expert surveyor, succeeded him. He introduced the correction lines and spherical provisions and perfected the system in its minor details.

A vote of thanks to Mr. Truesdell and immediate adjournment at 10 P.M.

C. L. ANNAN, *Secretary.*

Boston Society of Civil Engineers.

BOSTON, APRIL 20, 1904.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.30 o'clock P.M.; President Frederick Brooks in the chair. One hundred and thirty-two members and visitors present.

The record of the last meeting was read and approved.

The following were elected to membership in the Society as members: Messrs. Edmund M. Blake, Arthur H. Blanchard, Francis H. Boyer, Charles E. Chandler, Waldo S. Coulter, Frederick O. Gage, Winfred D. Hubbard, Robert Jerrett, Lionel S. Marks, Walter S. McKenzie, Ralph H. Stearns,

W. B. Smith Whaley, Wm. G. Wheelock, Jr., and as an associate, Mr. Hervey A. Hanscom.

The Secretary reported, for the Board of Government, the appointment of the following committees:

Committee on Excursions—F. M. Miner, E. P. Adams, E. F. Miller, W. H. Norris and F. E. Winsor.

Committee on Library—F. P. McKibben, K. S. Sweet, F. I. Winslow, J. N. Ferguson and R. S. Hale.

Committee on Advertisements—E. W. Howe, A. S. Glover and F. V. Fuller.

Committee on Quarters—Desmond Fitzgerald, E. W. Howe, C. F. Allen, E. W. Bowditch, G. A. Kimball, W. E. McClintock, I. N. Hollis, T. H. Barnes, F. W. Dean, F. C. Coffin, W. S. Johnson, W. E. McKay, C. W. Sherman, R. S. Weston, C. A. Stone, A. T. Safford and J. W. Ellis.

Members of Board of Managers, Association of Engineering Societies, in addition to the Secretary—J. R. Freeman, Henry Manley, Dexter Brackett and Dwight Porter.

The President then introduced Mr. W. L. R. Emmet, of the General Electric Company, who read a paper, entitled "The Steam Turbine in Modern Engineering." The paper was fully illustrated by lantern slides.

At the conclusion of the reading of the paper, on motion of Professor Hollis, the thanks of the Society were voted to Mr. Emmet for his very interesting paper.

On motion of Mr. McKibben, the following votes were passed:

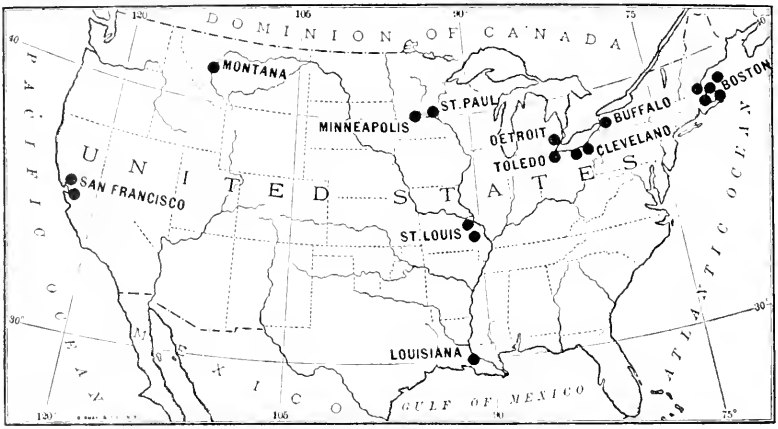
Voted: That the thanks of this Society be transmitted to the President and Directors of the American Telephone and Telegraph Company for the gift of 150 bound volumes of technical periodicals recently received.

Voted: That the privileges of the library and reading room of the Society be extended to the employees of the telephone company.

On motion of Mr. Miner, the thanks of the Society were voted to Mr. C. L. Edgar, President of the Edison Electric Illuminating Company, for courtesies extended to members of the Society on the occasion of the visit to the works of that company this afternoon.

Adjourned.

S. E. Tinkham, *Secretary.*



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

Association of Engineering Societies.

Vol. XXXII. **May, 1904.** No. 5.

PROCEEDINGS.

Engineers' Club of St. Louis.

578th Meeting, St. Louis, Mo., March 16, 1904.—Held at the Club Rooms, 709 Pine Street, Wednesday evening; Vice-President Moore presiding. There were present 33 members and 6 guests.

The minutes of the 576th and 577th meetings were read and approved, and the minutes of the 364th meeting of the Executive Committee were read.

Mr. Arthur A. Bonsack was elected to membership.

The paper of the evening, by Mr. Hugues Brussel, upon "Armored Concrete Construction," was ably presented, and was pleasingly illustrated by many lantern slides. The lateness of the hour prevented the discussion, which promised to be of great interest.

Adjourned.

R. H. Fernald, *Secretary.*

579th Meeting, St. Louis, Mo., April 6, 1904.—Held at the Club Rooms, 709 Pine Street, Wednesday evening.

With the exception of one or two ladies' nights, the Secretary was unable to find any record of attendance for the past 10 years larger than that of this meeting, there being 45 members and 19 visitors present.

The minutes of the 578th meeting were read and approved, and the minutes of the 365th meeting of the Executive Committee were read.

The Secretary read a letter from the Engineers' Society of Western Pennsylvania offering an exchange of privileges of club rooms, etc.

A letter from Mr. Chas. W. Hunt, Secretary of the International Engineering Congress, to be held in St. Louis, in October, was also read, asking the number of copies desired of the various papers to be presented at the meetings.

An invitation was presented from the Trustees and Faculty of the Case School of Applied Science, Cleveland, Ohio, requesting the Club to be represented by a delegate at the inauguration of Chas. Sumner Howe as President of the institution mentioned, May 11th.

The President was authorized to appoint a delegate.

A very kind invitation was extended to the members of the Club by Mr. Strickler, Superintendent of Construction of the Government Buildings at the Exposition, to visit the Government Building at their pleasure. Mr. Strickler especially requested that the members of the Club make themselves known to him personally that he might extend special courtesies.

The thanks of the Club were expressed to Mr. Strickler for his cordial invitation.

Mr. S. B. Russell, Chairman of the World's Fair Committee, made a brief report, indicating that the souvenir was nearly ready for publication.

The paper of the evening, upon "World's Fair Terminals of the Local Traction Companies and Proposed Methods of Handling Visitors to the Exposition," by Mr. C. A. Moreno, was of unusual and timely interest, and was immediately captured by the *Globe-Democrat* for publication.

A lively discussion followed the reading of the paper, and was participated in by Messrs. Wheeler, Russell, Pfeifer, Perkins, Langsdorf, Smith, Ockerson, Flad, Greensfelder, Van Ornum, Bouton, Phillips and Moreno.

The following paper was announced for the next meeting, April 20th: "Side-Lights on South Africa, Past and Present," by Capt. A. W. Lewis, Manager of the South African Boer War Exhibit Co. at the Exposition.

Adjourned.

R. H. Fernald, *Secretary.*

580th Meeting, St. Louis, Mo., April 20, 1904.—The meeting was held at the Club Rooms, 709 Pine Street, Wednesday evening, April 20, 1904. Vice-President Moore presided.

There were present 26 members and 20 visitors.

The minutes of the 579th meeting were read and approved, and the minutes of the 366th meeting of the Executive Committee were read.

A letter from the Civil Engineers' Club of Boston, offering an exchange of Club Room privileges, was read.

The paper of the evening, entitled "Side Lights on South Africa, Past and Present," was most ably presented by Capt. A. W. Lewis, Manager of the South African Boer War Exhibit Company at the Exposition.

Captain Lewis outlined the South African conditions and the details of the war in an exceedingly interesting and impartial manner.

At the conclusion of the remarks by Captain Lewis, General Cronje consented to address the Club, through his interpreter, Lieutenant Von Peters, and was heartily received and listened to with great interest and pleasure.

The discussion, which consisted largely of inquiries of Captain Lewis and General Cronje regarding the labor and mining conditions of that portion of that country, was participated in by Messrs. Moore, Moreno, Wheeler, Humphrey and Thompson.

A paper entitled "Graphical Methods for Determining the Equations of Experimental Curves," by A. S. Langsdorf, was read by title and ordered forwarded for publication in the Journal. Adjourned.

R. H. Fernald, *Secretary.*

Technical Society of the Pacific Coast.

Regular Meeting, San Francisco, Cal., April 1, 1904.—Called to order at 8.30 o'clock p.m., by President Dickie, who stated that the meeting was held for the purpose of transacting the running business of the Society.

The minutes of the last regular meeting were read and approved.

The following gentlemen were elected to membership: W. Jones Cuthbertson, architect, San Francisco; C. J. Wheeler, chemist, Portland Cement Company, Suisun, Cal,

The following applications for membership were made:

For Members—1. Hugh C. Banks, civil engineer, San Francisco. Refers to Patrick Noble, R. G. Doerfling and C. E. Grunsky.

2. Robert McF. Doble, consulting engineer, San Francisco. Refers to John Richards, Geo. W. Dickie and Otto von Geldern.

For Associate—3. Chas. S. Girvan, Western Fuel Company, San Francisco. Refers to Franklin Riffle, Stetson G. Hindes, Loren E. Hunt and Howard C. Holmes.

In the further discussion of the coming spring meeting and its arrangements, the following details were agreed upon:

That ladies be invited to all social functions, including the banquet.

That all members be notified of this again.

That they indicate on return cards:

1. Whether city members will entertain visiting members, and, if so, how many each one will accommodate?

2. How many will attend the banquet, including the guests of each member?

That a certain number of invitations be issued to prominent men and well-known engineers, such as the Presidents of the universities, the engineering faculties, Lick Observatory director, army and naval engineers, the Mayor of the city and others, who are to be the guests of the Society for the evening.

That the President have power to confer with the trustees of the Academy of Sciences, and perfect an arrangement to obtain the lecture hall of the Academy for the purpose of the Society's meetings in May.

The Secretary was instructed to notify all members of the Technical Society that they are invited to become members of the International Engineering Congress, which is to be held in St. Louis, October 3 to 8, 1904, under the auspices of the American Society of Civil Engineers, and that our members are requested to participate in its proceedings, either in person or by written communications forwarded to the Secretary, on any of the subjects that have been chosen for consideration.

Mr. Loren E. Hunt explained at length the laboratory work of timber testing as done at the University of California, and called attention to the fact that there were at the present time two bills in the hands of a Congressional Committee for the purpose of creating an appropriation for carrying on the very useful work of testing the timbers of the United States. He suggested that the Society call the attention of the California representation in Congress to these bills, and that the support of these measures be urged.

The following resolution was then introduced and unanimously carried:

Resolved, That the Secretary of the Society, on behalf of the members, address a letter to our Senators and Representatives in Congress, calling attention to the so-called "Timber Test" bills, and requesting them to use their best influence and to give their individual support to these measures, which are of vital interest not only to the engineering professions, but also to one of the great industries of the North Pacific Coast.

Resolved, also, That the Secretary be instructed to write an individual and earnest appeal to Senator Perkins to take up this important matter.

No further business appearing, the meeting adjourned.

OTTO VON GELDERN, *Secretary*.

Civil Engineers' Club of Cleveland.

CLEVELAND, OHIO, APRIL 12, 1904.—The regular meeting was called to order at 8.15 P.M. with 36 members present; President Alexander E. Brown in the chair.

The applications of Messrs. F. W. Carroll, E. B. Thomas and W. L. Westcott were reported to the Club with the approval of the Executive Board. The President announced the appointment of the following committee to consider legislation pending in the State Legislature relative to the creation of the office of County Engineer: Messrs. Warner, Gibbs, Handy, Osborn and Barren. The President also announced the appointment of Mr. Ambrose Swasey to represent the Club at the inauguration of Mr. Charles S. Howe as President of the Case School of Applied Science.

Mr. C. H. Wright, Chairman of the Annual Banquet Committee, reported adversely on that proposition: First, because the retiring President had left the city, thus removing the motive for such a banquet; second, that considerable demands would be made upon the Club's treasury during the coming summer for the entertainment of visiting engineers; third, that it seemed desirable to center all the Club's energies on the celebration of the twenty-fifth anniversary, which occurs on March 13, 1905. The report was accepted and the committee discharged.

Mr. Gobeille, Chairman of the House Committee, submitted a report of the operation of that committee from the time of its establishment to the present, together with a resolution to extend the arrangement three years longer. The report was accepted and the resolution adopted. In lieu of a regular paper there was a discussion of the various phases of the "Grade Crossing Problem," led by Mr. W. J. Carter, City Engineer, and Mr. James Ritchie, lately Engineer for the Grade Crossing Commission.

JOE C. BEARDSLEY, *Secretary*.

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., MAY 9, 1904.—A regular meeting of the Civil Engineers' Society of St. Paul was held at the City Hall at 9 P.M.

President Starkey and seven members present.

Minutes of previous meeting read and approved.

Communications received:

March 12th From Charles Warren Hunt inclosing Circular No. 2 International Engineering Congress. Referred to Secretary.

March 26th—Circular letter from *Railroad Gazette*. It was the unanimous opinion of the meeting that paper 9 x 12 inches would be more convenient than the one of 10½ x 15½ inches for reading and filing; also that it would be preferable to fold "some detail drawings" rather than to reduce the scale of same.

March 26th—From the Engineers' Society of Western Pennsylvania and April 7th from the Boston Society of Civil Engineers, both as to exchange of privileges of library and reading room on presentation of membership card.

The Secretary was instructed to inform both Societies of the readiness of the St. Paul Society to exchange courtesies.

The Society failed to name a delegate to attend the inauguration of the President of the Case School of Applied Science at Cleveland on May 11, 1904.

The President appointed the following examining board: A. O. Powell, A. W. Munster and C. A. Winslow.

A discussion as to increasing the membership of the Society resulted in the appointment of each member present as an independent committee on solicitation with orders to report progress at a special meeting to be called in June.

Adjourned at 10.30 P.M.

C. L. ANNAN, *Secretary.*

Montana Society of Engineers.

THE regular monthly meeting of the Society was held April 9th, in the Society room in the Tuttle Block, at 8 P.M.

There was an unusually large number of members in attendance, as well as ten students from the State School of Mines. At the regular hour the meeting was called to order, Mr. McArthur in the chair. The minutes of the last meeting were read and approved. Messrs. McNulta and McCulloh were unanimously elected to membership in the Society. The Secretary presented the application of James H. McCormick for membership, and, on approval, ballots were ordered circulated. Mr. Charles Metlicka was chosen a delegate to the inauguration of Charles Sumner Howe as President of Case School of Applied Science, Cleveland, Ohio, May 11th.

The Secretary gave notice that the Society must vacate its present quarters, and Messrs. Moulthrop, Harper and Moore were appointed a committee to secure another room.

Mr. Joseph H. Harper gave a very instructive talk on the subject of "Mine Surveying," illustrating his views by practical applications, explaining the various uses of an assortment of engineering instruments at hand, as well as a simple invention of his own. Messrs. Barker, Vail, McDonald, E. H. and others contributed their experiences to Mr. Harper's, and a very interesting meeting closed with adjournment.

CLINTON H. MOORE, *Secretary.*

Association of Engineering Societies.

VOL. XXXII. **JUNE, 1904.** No. 6.

PROCEEDINGS.

Boston Society of Civil Engineers.

BOSTON, MASS., MAY 18, 1904.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.45 oclock P.M.; President Fred. Brooks in the chair. Sixty-two members and visitors present.

The record of the last meeting was read and approved.

The following were elected to membership in the Society, as members: Messrs. Theodore O. Barnard, Richard Hutchison, Herbert S. Kimball, George W. Mansur, Walter B. Snow and William L. Tobey, and as an associate, Mr. Charles S. Clark.

On motion of Mr. Winsor, the thanks of the Society were voted to Mr. John C. Sanborn, general manager, and to Mr. Edwin J. Beugler, resident engineer, of the Boston Terminal Co., also to the officials of the New York, New Haven & Hartford Railroad Co., who extended courtesies to the Society on the occasion of the excursion to the South Station and to the railroad improvements at South Boston.

The paper of the evening was read by Prof. Charles L. Norton, of the Massachusetts Institute of Technology, entitled "Lessons from the Baltimore Conflagration." The paper was illustrated with lantern slides.

A short discussion followed, in which Prof. F. B. Sanborn, Mr. E. S. Larned, Prof. Norton and others took part.

After passing a vote of thanks to Prof. Norton for the paper of the evening, the Society adjourned.

S. E. TINKHAM, *Secretary*.

BOSTON, MASS., JUNE 15, 1904.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.30 o'clock P.M.; President Frederick Brooks in the chair. Forty-five members and visitors present.

The record of the last meeting was read and approved.

The following were elected to membership in the Society: As members, Messrs. J. Ansel Brooks, Frank P. Cobb, George D. Emerson, Erwin O. Hathaway, Chester S. Jennings, Frank P. Kennedy, George N. Merrill, William F. Sullivan, and as an associate, Mr. William F. Kearns.

On motion of Mr. Miner, the thanks of the Society were voted to Mr. John F. Fife, Chief Engineer, at Jordan-Marsh Company, and to Mr. W. R.

Fairfield, of Hearst's *Boston American*, for courtesies extended to members of the Society on June 15, 1904.

On motion of the Secretary, the thanks of the Society were voted to Miss Tidd for the gift of a framed portrait of her father, the late Marshal M. Tidd, an honored member of the Society.

The President announced the death of Charles W. Folsom, one of the oldest members of the Society, which occurred on May 19, 1904, and by vote of the Society the President was requested to appoint a committee to prepare a memoir. The following have been appointed as members of that committee: Messrs. Charles W. Kettell, William H. Bradley and Edgar S. Dorr.

Mr. Stephen Child read the paper of the evening, entitled "Landscape Architecture," which was fully illustrated by lantern slides. A general discussion followed in which Messrs. Stearns, Howe, French, Bryant, Hale, Porter and others took part.

Adjourned.

S. E. Tinkham, *Secretary.*

Engineers' Club of St. Louis.

582d Meeting, St. Louis, Mo., May 18, 1904.—The meeting was held at the Club rooms, 709 Pine Street, Wednesday evening, May 18th; President Ockerson presiding.

There were present twenty members and six guests.

The minutes of the 581st meeting were read and approved, and the minutes of the 368th meeting of the Executive Committee were read.

The memorial upon the death of Mr. Geo. W. Fischer, a charter member of the Club, prepared by Messrs. Julius Pitzman, Robert E. McMath and Wm. Wise, was read by the Secretary.

Upon motion of Mr. Bryan, it was ordered spread on the records of the Club and copies ordered sent to Mr. Fischer's children.

The President announced a cordial invitation from Dr. Lewald to the Club to be present at the formal opening of the Engineering Section of the German Exhibit, in the Liberal Arts Building, Friday morning, May 20th, at eleven o'clock.

Mr. Lionel Viterbo was elected to membership in the Club.

Dr. W. J. McGee, Washington, D. C., Chief of the Department of Anthropology at the Exposition, gave a most interesting informal talk on "The Sheetfloods of the Arid Regions and their Relation to Engineering."

The subject was discussed by Messrs. Burgess, Helm, Ockerson, Russell and Dr. McGee.

The President expressed the appreciation and thanks of the Club to Dr. McGee for his kindness in responding to the invitation to address the Club.

Mr. S. B. Russell gave notice of the Good Roads Convention, now in progress in the city, and urged the members of the Club to attend the meetings.

Adjourned. R. H. Fernald, *Secretary.*

Technical Society of the Pacific Coast.

Directors' Meeting, San Francisco, Cal., April 22, 1904.—Held at the residence of President George W. Dickie, at San Mateo, who had invited the Board of Directors to dinner.

Present, Directors Dickie, Riffle, Schild, Molera, Wing, Connick, Lietz, Uhl'g and Von Geldern.

After the dinner the meeting was called to order by the President, and the details of the spring meeting were arranged, as outlined on the program.

Arrangements for the banquet were left in the hands of Messrs. Dickie and Schild.

After a most pleasant evening spent at the San Mateo home of the President, the party returned to San Francisco.

Otto von Geldern, *Secretary.*

Regular Meeting, San Francisco, Cal., May 6, 1904.—Called to order at 8.30 p.m. by President Dickie.

The minutes of the last regular meeting were read and approved.

The following names were added to the list of membership:

Members—Robert McF. Doble, consulting engineer, San Francisco; Hugh C. Banks, civil engineer, San Francisco; C. H. Snyder, civil engineer, San Francisco.

Associate member—Chas. S. Girvan, of the Western Fuel Company, San Francisco.

The President thereupon introduced to the members Mr. Joseph R. Oldham, N.A., who read a most interesting paper on the subject, "The Rise and Fall of the American Merchant Marine and Progress in Ship Design and Construction."

This very important subject was discussed at length by President Dickie, who gave some of his experiences in the line of ship construction and the rehabilitation of ocean commerce in American bottoms.

The author was thanked and a vote of appreciation passed for the courtesy extended to the Society in preparing and reading the paper.

Adjourned.

Otto von Geldern, *Secretary.*

Detroit Engineering Society.

Detroit, Mich., April 29, 1904.—The tenth annual meeting of the Detroit Engineering Society was held in the parlors of the Hotel Ste. Claire. The following officers were elected.

President—T. H. Hinchman, Jr.

First Vice-President—J. D. Sanders.

Second Vice-President—Benjamin Douglas.

Secretary-Treasurer—Clarence W. Hubbell.

After the election of officers the Society adjourned to the hotel dining room, where the tenth annual banquet was served, 66 members being present.

The following is the list of toasts presented at the banquet:

1. "Progress in Railroad Bridge Building," President F. C. McMath.
2. "The University of Michigan," Prof. M. E. Cooley.
3. "The Michigan Agricultural College," Prof. C. L. Weil.
4. Song, Member A. F. Dierkes.
5. "Future Possibilities in Electrical Engineering," Member Alex. Dow.
6. "Recent Progress in Hydraulic Engineering," Prof. Gardner S. Williams.
7. "The Beautiful in Engineering," Member W. S. Russell.
8. "Health and Sanitation," Member A. B. Raymond.
9. Address, President-elect T. H. Hinchman, Jr.

LISTS OF MEMBERS

OF THE SOCIETIES COMPOSING THE

Association of Engineering Societies.

DECEMBER 31, 1903.

	Members.	Page.
Boston Society of Civil Engineers	520	1
Civil Engineers' Club of Cleveland	224	27
Engineers' Club of St. Louis	234	39
Civil Engineers' Society of St. Paul	60	51
Engineers' Club of Minneapolis	93	54
Montana Society of Engineers	160	59
Technical Society of the Pacific Coast	157	66
Detroit Engineering Society	110	74
Engineers' Society of Western New York	81	79
Louisiana Engineering Society	64	83
Total	1712	

Lists of Members of the Associated Societies.

Abbreviations for designating membership:

MEM.	FOR MEMBER.
HON. MEM.	FOR HONORARY MEMBER.
ACT. MEM.	FOR ACTIVE MEMBER.
ASSOC. MEM.	FOR ASSOCIATE MEMBER.
COR. MEM.	FOR CORRESPONDING MEMBER.
JUN. MEM.	FOR JUNIOR MEMBER.
ASSOC.	FOR ASSOCIATE.
JUN.	FOR JUNIOR.

Boston Society of Civil Engineers.

ADAMS, EDWARD P., Mem.,
Landscape Architect and Civil Engineer,
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ADAMS, HENRY S., Mem.,
Civil Engineer, 71 Ames Building, Boston, Mass.

ADDICKS, WALTER R., Mem.,
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AIKEN, CHARLES W., Mem.,
Consulting Engineer, 82 Washington street, New York, N. Y.

AIKEN, ROY C., Mem.,
Civil Engineer, cor. Atlantic and Prospect streets, Atlantic, Mass.

ALLARD, THOMAS T., Mem.,
Civil Engineer. Southport, N. C.

ALLEN, C. FRANK, Mem.,
Professor of Railroad Engineering, Mass. Inst. of Technology,
Boston, Mass.

ALLEN, CHARLES A., Mem.,
Consulting Engineer, 44 Front street, Worcester, Mass.

ANDREWS, DAVID H., Mem.,
President, Boston Bridge Works, 47 Winter street, Boston, Mass.

ARMSTRONG, SAMUEL G., Mem.,
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ASPINWALL, THOMAS, Mem.,
Aspinwall & Lincoln, Civil Engineers,
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ATWOOD, JOSHUA, 3d, Mem.,
Chief Engineer, Paving Division, Street Department, Boston,
70 City Hall, Boston, Mass.

BADGER, FRANK S., Mem.,
Assistant Engineer, United States Geological Survey,
Wadsworth, Nev.

BAILEY, ERNEST W., Mem.,
City Engineer, City Hall, Somerville, Mass.

BAILEY, FRANK S., Mem.,
Civil Engineer, 177 Washington street, Weymouth, Mass.

BAILEY, WILLIAM M., Mem.,
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BALDWIN, LOAMMI F., Mem.,
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BANCROFT, LEWIS M., Mem.,
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BARBOUR, FRANK A., Mem.,
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BARNES, T. HOWARD, Mem.,
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BARNES, WILLIAM T., Mem.,
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BATEMAN, LUTHER H., Mem.,
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BETTON, JAMES M., Mem.,
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BIDWELL, LAWSON B., Mem.,
District Engineer, Eastern District, N. Y., N. H. and H. R. R.,
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BIGELOW, JAMES F., Mem.,
City Engineer, 15 Corey Bldg., Marlboro, Mass.
BISSELL, H., Mem.,
Chief Engineer, Boston and Maine Railroad, Boston, Mass.
BLAKE, FRANCIS, Mem.,
Auburndale, Mass.
BLAKE, PERCY M., Mem.,
Civil and Hydraulic Engineer, Newtonville, Mass.
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BLOOD, JOHN BALCH, Mem.,
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BLOSSOM, WILLIAM L., Mem.,
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BOLTON, EDWARD D., Mem.,
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BORDEN, PHILIP D., Mem.,
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BRADLEY, WILLIAM H., Mem.,
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Buff, Louis F., Mem.,
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EVANS, ROBERT R., Mem.,
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FALES, FRANK L., Mem.,
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FERGUSON, HARDY S., Mem.,
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FERGUSON, JOHN N., Mem.,
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FERNALD, GEORGE N., Mem.,
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FITZGERALD, DESMOND, Mem.,
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FOSS, WILLIAM E., Mem.,
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FOSTER, WALTER B., Mem.,
Civil Engineer, Hingham, Mass.
FOSTER, WILLARD M., Mem.,
Engineer, Spier Falls Dam, Glens Falls, N. Y.
FRANCIS, GEORGE B., Mem.,
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FREEMAN, JOHN R., Mem.,
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FRENCH, ALEXIS H., Mem.,
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FRIZELL, JOSEPH P., Mem.,
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CONTENTS AND INDEX.

VOLUME XXXIII.

July to December, 1904.

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CONTENTS.

VOL. XXXIII, July–December, 1904.

For alphabetical index, see page v.

No. 1. JULY. PAGE

Landscape Architecture. *Stephen Child* 1
Suggestions for Steel-Concrete Construction. *John Anderson* 9
The Purification of Water. *Prof. John M. Ordway* 12
Boiler and Engine Test of a Small Steamboat 21

No. 2. AUGUST.

Ore-Handling Plant at the Clairton Works of the Crucible Steel Company. *Charles H. Wright* 25
Mechanical Flight. *J. Emery Harriman, Jr., C.E.* 43
Ferroinclave and Cornell's Patent Dovetailed Lath. *H. C. Harrower.* 54
On Contemporary Technical Education. *John R. Freeman* 58

No. 3. SEPTEMBER.

Papers and Discussions by the Technical Society of the Pacific Coast. Spring Meeting, 1904:
Engineering on the Pacific Coast. *Geo. W. Dickie* 73
Laying of the Commercial Pacific Cable. *Frank P. Medina* 85
Simple Steam Turbine Engines. *John Richards* 93
The Reclamation of a Mountain Swamp. *Marsden Manson* 115
Pipes and Joints for High Pressures. *Franklin Riffle* 122
Vertical Railway Curves. *H. I. Randall* 135
Concrete-Steel. *M. C. Couchot* 157
A New Method of Building Construction. *S. Giletti* 163
Manufacture and Testing of Portland Cement. *C. J. Wheeler* 169
The Comparative Economy of Various Types of Highway Bridges. *C. B. Wing* 180
The Jet Pump as an Hydraulic Apparatus. *F. G. Hesse* 187
Observations on Driving Piles with a Steam Hammer. *J. J. Welsh* ... 193

Proceedings.

No. 4. OCTOBER. PAGE

The Cleaning and Flushing of Sewers.

Discussion.

By the Sanitary Section of the Boston Society of Civil Engineers..... 199
By *J. L. Woodfall, Leonard Metcalf, William S. Johnson, Freeman C. Coffin, W. D. Hubbard, C. R. Felton, Bertram Brewer, Mr. Hastings, W. C. Parmley, Dana Libby, E. S. Dorr, F. Herbert Snow, W. D. Hunter, T. Howard Barnes, F. G. Berry, Harrison P. Eddy, Geo. A. Wetherbee, A. C. Townsend, E. W. Branch, Mr. Fuller, F. A. Barbour, W. H. Patterson, A. A. Adams, E. C. Frost, George Bowers.*

Fable and Fact as Factors of Progress. *J. L. Van Ornum*............ 248

The Disposal of Municipal Refuse. *F. K. Rhines*.................. 255

Proceedings.

No. 5. NOVEMBER.

The Main Intercepting Sewers of Cleveland, Ohio. *Walter C. Parmley* 271

Vital Statistics of St. Louis Since 1840. *Robert Moore*.............. 299
Discussion. *Dr. S. W. Abbott, Allen Hazen, Dr. G. Baumgarten, Dr. John Green, Robert Moore.*

The Classification of Engines for Bridge Loading. *C. D. Purdon*..... 325

Obituary—
Charles William Folsom.. 329

Proceedings.

No. 6. DECEMBER.

The Water Supply of Minneapolis. *J. Frank Corbett, M.D.*........... 331

A Recent Visit to Twenty-four British Sewage Works. *M. N. Baker*.. 336
Discussion. *The Chairman; H. W. Clark, Mr. Fuller, Prof. Leonard P. Kinnicutt, T. H. McKenzie, Mr. Baker.*

Isthmus Canal: Sea Level *vs.* Locks. *Wm. W. Redfield*............ 363

Obituary—
Kilburn Smith Sweet 368

Proceedings.

INDEX.

VOL. XXXIII, July–December, 1904.

The six numbers were dated as follows:

No. 1, July.	No. 3, September.	No. 5, November.
No. 2, August.	No. 4, October.	No. 6, December.

ABBREVIATIONS.—P = Paper; D = Discussion; I = Illustrated.
Names of authors of papers, etc., are printed in *italics*.

PAGE

Anderson, John C.——. Suggestions for Steel-Concrete Construction. P., I., July, 9
Architecture, Landscape——. *Stephen Child*..............P., I., July, 1

Baker, M. N.——. A Recent Visit to Twenty-four British Sewage Works ....P., Dec., 336
Boiler and Engine Test of a Small Steamboat. *Warren Johnson.* P., July, 21
Boston Society of Civil Engineers, Sanitary Section of——. Discussion on the Cleaning and Flushing of Sewers..............I., Oct. 199
Bridge Loading, Classification of Engines for——. *C. D. Purdon.* P., I., Nov., 325
Bridges, Highway——. Comparative Economy of Various Types of——. *C. B. Wing* ....P., Sept., 180
British Sewage Works, A Recent Visit to Twenty-four——. *M. N. Baker* ....Dec., 336
Building Construction, a New Method of——. *S. Giletti*..P., I., Sept., 163

Cable, the Commercial Pacific——, Laying of the——. *Frank P. Medina* ....P., Sept., 85
Canal, Isthmus——: Sea Level *vs.* Locks. *Wm. W. Redfield*..P., Dec., 363
Cement, Portland——, Manufacture and Testing of——. *C. J. Wheeler.* P., Sept., 169
Child, Stephen——. Landscape Architecture..............P., I., July, 1
Clairton Works of the Crucible Steel Company, Ore-Handling Plant at the——. *Chas. H. Wright*..............P., I., Aug., 25
Classification of Engines for Bridge Loading. *C. D. Purdon.* P., I., Nov., 325
Cleaning and Flushing of Sewers. Discussion by the Sanitary Section of the Boston Society of Civil Engineers..............I., Oct., 199

PAGE

Cleveland, Ohio——, The Main Intercepting Sewers of——. *Walter C. Parmley* ....P., I., Nov., 271
Comparative Economy of Various Types of Highway Bridges. *C. B. Wing* ....P., Sept., 180
Concrete, Steel-——Construction——, Suggestions for——. *John C. Anderson* ....P., I., July, 9
Concrete-Steel. *M. C. Couchot*....P., I., Sept., 157
Contemporary Technical Education. *John R. Freeman*......P., Aug., 58
Corbett, J. Frank——M.D.——. Water Supply of Minneapolis. P., I., Dec., 331
Cornell's Patent Dovetailed Lath, Ferroinclave and——. *H. C. Harrower* ....P., D., I., Aug., 54
Couchot, M. C.——. Concrete-Steel....P., I., Sept., 157
Crucible Steel Company, Ore-Handling Plant at the Clairton Works of the——. *Chas. H. Wright*....P., I., Aug., 25
Curves, Railway——, Vertical——. *H. I. Randall*........P., I., Sept., 135

Dickie, Geo. W.——. Engineering on the Pacific Coast......P., Sept., 73
Disposal of Municipal Refuse. *F. K. Rhines*....P., Oct., 255

Education, On Contemporary Technical——. *John R. Freeman.* P., Aug., 58
Engine, Boiler and——, Test of a Small Steamboat. *Warren Johnson.* P., July, 21
Engineering on the Pacific Coast. *George W. Dickie*........P., Sept., 73
Engines, Classification of——, for Bridge Loading. *C. D. Purdon.* P., I., Nov., 325
Engines, Simple Steam Turbine——. *John Richards*.....P., I., Sept., 93

Fable and Facts as Factors of Progress. *J. L. Van Ornum*..P., Oct., 248
Ferroinclave and Cornell's Patent Dovetailed Lath. *H. C. Harrower.* P., D., I., Aug., 54
Flight, Mechanical——. *J. Emery Harriman, Jr., C.E.*....P., I., Aug., 43
Flushing, Cleaning and——, of Sewers. Discussion by the Sanitary Section of the Boston Society of Civil Engineers..........I., Oct., 199
Folsom, Charles William——. Obituary. Boston Society of Civil Engineers ....Nov., 329
Freeman, John R.——. On Contemporary Technical Education. P., Aug., 58

Gilleti, S.——. A New Method of Building Construction..P., I., Sept., 163

Hammer, Steam——, Driving Piles with a——, Observations on——. *J. J. Welsh* ....P., Sept., 193
Harriman, J. Emery——Jr.——. Mechanical Flight ......P., I., Aug., 43
Harrower, H. C.——. Ferroinclave and Cornell's Patent Dovetailed Lath ....P., D., I., Aug., 54
Hesse, F. G.——. The Jet Pump as an Hydraulic Apparatus. P., I., Sept., 187

PAGE

Highway Bridges, Comparative Economy of Various Types of——. *C. B. Wing*....P., Sept., 180
Hydraulic Apparatus, The Jet Pump as an——. *F. G. Hesse.* P., I., Sept., 187

Intercepting Sewers of Cleveland, Ohio, The Main——. *Walter C. Parmley*....P., I., Nov., 271
Isthmus Canal: Sea Level *vs.* Locks. *Wm. W. Redfield*....P., Dec., 363

Jet Pump as an Hydraulic Apparatus. *F. G. Hesse*....P., I., Sept., 187
Johnson, Warren——. Boiler and Engine Test of a Small Steamboat. P., July, 21
Joints, Pipes and——, for High Pressures. *Franklin Riffle*..P., I., Sept., 122

Landscape Architecture. *Stephen Child*....P., I., July, 1
Lath, Cornell's Patent Dovetailed——, Ferroinclave and——. *H. C. Harrower*....P., D., I., Aug., 54
Laying of the Commercial Pacific Cable. *Frank P. Medina*..P., Sept., 85
Loading, Bridge——, Classification of Engines for——. *C. D. Purdon.* P., I., Nov., 325
Locks, Sea Level *vs.*——, Isthmus Canal:——. *Wm. W. Redfield.* P., Dec., 363
Locomotives, Classification of——, for Bridge Loading. *C. D. Purdon.* P., I., Nov., 325

Main Intercepting Sewers of Cleveland, Ohio. *Walter C. Parmley.* P., I., Nov., 271
Manson, Marsden——. Reclamation of a Mountain Swamp........ P., I., Sept., 115
Manufacture and Testing of Portland Cement. *C. J. Wheeler.* P., Sept., 169
Mechanical Flight. *J. Emery Harriman, Jr., C.E.*....P., I., Aug., 43
Medina, Frank P.——. Laying of the Commercial Pacific Cable. P., Sept., 85
Minneapolis, Water Supply of——. *J. Frank Corbett, M.D.* P., I., Dec., 331
Moore, Robert——. Vital Statistics of St. Louis Since 1840. P., D., I., Nov., 299
Municipal Refuse, Disposal of——. *F. K. Rhines*....P., Oct., 255

New Method of Building Construction. *S. Giletti*....P., I., Sept., 163

Obituary—
Charles William Folsom....Nov., 329
Kilburn Smith Sweet 368
Observations on Driving Piles with a Steam Hammer. *J. J. Welsh.* P., Sept., 193
On Contemporary Technical Education. *John R. Freeman*...P., Aug., 58

PAGE
Ordway, John M.——. The Purification of Water...........P., July, 12
Ore-Handling Plant at the Clairton Works of the Crucible Steel Company. *Charles H. Wright*...........................P., I., Aug., 25

Pacific Coast, Engineering on the ——. *Geo. W. Dickie*......P., Sept., 73
Parmley, Walter C.——. Main Intercepting Sewers of Cleveland, Ohio ....P., I., Nov., 271
Piles, Driving——, with a Steam Hammer——. Observations on——. *J. J. Welsh*..P., Sept., 193
Pipes and Joints for High Pressures. *Franklin Riffle*.....P., I., Sept., 122
Portland Cement, Manufacture and Testing of——. *C. J. Wheeler*. P., Sept., 169
Pump, The Jet——, as an Hydraulic Apparatus. *F. G. Hesse*. P., I., Sept., 187
Purdon, C. D.——. The Classification of Engines for Bridge Loading. P., I., Nov., 325
Purification of Water. *Prof. John M. Ordway*..............P., July, 12

Railway Curves, Vertical——. *H. I. Randall*............P., I., Sept., 135
Randall, H. I.——. Vertical Railway Curves.............P., I., Sept., 135
Recent Visit to Twenty-four British Sewage Works. *M. N. Baker*. P., Dec., 336
Reclamation of a Mountain Swamp. *Marsden Manson*....P., I., Sept., 115
Redfield, Wm. W.——. Isthmus Canal: Sea Level *vs.* Locks..P., Dec., 363
Refuse, Municipal——, Disposal of——. *F. K. Rhines*........P., Oct., 255
Rhines, F. K.——. Disposal of Municipal Refuse............P., Oct., 255
Richards, John——. Simple Steam Turbine Engines....P., I., Sept., 93
Riffle, Franklin——. Pipes and Joints for High Pressures. P., I., Sept., 122
Sea Level *vs.* Locks, Isthmus Canal:——. *Wm. W. Redfield*..P., Dec., 363

Sewage Works, British——, A Recent Visit to Twenty-four——. *M. N. Baker* ....P., Dec., 336
Sewers, Cleaning and Flushing of——. Discussion by the Sanitary Section of the Boston Society of Civil Engineers..........I., Oct., 199
Sewers, Main Intercepting——, of Cleveland, Ohio. *Walter C. Parmley*. P., I., Nov., 271
Simple Steam Turbine Engines. *John Richards* ....P., I., Sept., 93
Steamboat, Boiler and Engine Test of a Small——. *Warren Johnson*. P., July, 21
Steam Hammer, Driving Piles with a——, Observations on——. *J. J. Welsh* ....P., Sept., 193
Steam Turbine Engines, Simple——. *John Richards*....P., I., Sept., 93
Steel Company, The Crucible——, Ore-Handling Plant at the Clairton Works of the——. *Charles H. Wright*.............P., I., Aug., 25
Steel, Concrete- ——. *M. C. Couchot*.....................P., I., Sept., 157
Steel-Concrete Construction, Suggestions for——. *John C. Anderson*. P., I., July, 9

PAGE

St. Louis, Vital Statistics of——, Since 1840. *Robert Moore.* P., D., I., Nov., 299

Suggestions for Steel-Concrete Construction. *John C. Anderson.* P., I., July, 9

Swamp, Mountain——, Reclamation of a——. *Marsden Manson.* P., I., Sept., 115

Sweet, Kilburn Smith——. Obituary. Boston Society of Civil Engineers 368

Turbine Engines, Simple Steam——. *John Richards*.....P., I., Sept., 93

Van Ornum, J. L.——. Fable and Fact as Factors of Progress. P., Oct., 248

Vertical Railway Curves. *H. L. Randall*................P., I., Sept., 135

Vital Statistics of St. Louis Since 1840. *Robert Moore*..P., D., I., Nov., 299

Water, The Purification of——. *Prof. John M. Ordway*......P., July 12

Water Supply of Minneapolis. *J. Frank Corbett, M.D.*....P., I., Dec., 331

Welsh, J. J.——. Observations on Driving Piles with a Steam Hammer. P., Sept., 193

Wheeler, C. J.——. Manufacture and Testing of Porcelain Cement. P., Sept., 169

Wing, C. B.——. Comparative Economy of Various Types of Highway Bridges ....P., Sept., 180

Wright, Charles H.——. Ore-Handling Plant at the Clairton Works of the Crucible Steel Company....................P., I., Aug., 25

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VOL. XXXIII. JULY, 1904. NO. 1.

LANDSCAPE ARCHITECTURE.

BY STEPHEN CHILD, MEMBER OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS AND BOSTON SOCIETY OF CIVIL ENGINEERS.

[A lecture delivered before the Boston Society of Civil Engineers, June 15, 1904.*]

WE frequently hear nowadays the questions, "What is landscape architecture and what does a landscape architect do?"

Believing, as I do, that this subject is one that may interest the engineering profession (and it is certainly one that comes in very close touch with engineering in many ways), it is my purpose this evening to try in a few words to define more clearly the meaning of the term landscape architecture; and through the courtesy of Mr. Pray, of the Department of Landscape Architecture, Harvard University, who has kindly furnished me with some of the very valuable lantern slides owned by that department, I shall be able to show on the screen a few illustrations. These, I trust, will be of interest as indicating, perhaps better than could be done in any other way, the scope of this new profession and some of the results attained by those who have practiced it both in this country and abroad.†

At the present time, even among intelligent writers, there is the greatest possible confusion and apparent misunderstanding of the terms landscape architect and landscape gardener. Recent discussion of these terms has even brought out the opinion that this

* Manuscript received July 18, 1904.—Secretary, Ass'n of Eng. Socs.

† During the course of the lecture some 50 lantern slides were shown, a few of which are reproduced through the courtesy of the *Municipal Journal and Engineer*, of New York, the lecture having been adapted from an article by the author published in that magazine for January, 1904.

calling a man a landscape architect instead of a landscape gardener is merely a "recent fad," and that the idea is absurd, "filling one's mind with images of quarries, stonecutters, creaking derricks, tapping trowels and the like, instead of with pictures of freehand dealings with sunshine and shadow, trees, flowering shrubs and leaping fountains."

I am going to ask you to look at this a little more carefully with me and see what is true in this discussion. In the first place, the term is not a "recent fad." Frederick Law Olmsted, the elder, called himself a landscape architect away back in 1856, when he first entered upon the work of developing Central Park in New York City, and the fact that he did so, and continued to so designate himself during the whole of his career, has had much to do with the general adoption of the term. But the fact that one man, even an eminent one, adopted this title is perhaps not entirely sufficient, although those of us who are familiar with Mr. Olmsted's work and with his wonderful genius and mastery of the subject in all of its details may well feel assured that he did not adopt the title without most careful thought. Unfortunately he did not in his writings, so far as I am aware, really explain his reason. He was so immersed in the great battle, then going on, for public parks for large cities, in showing their value and necessity and in laying down the principles and executing the work of these great undertakings, that he apparently had little time to explain fully why he assumed the title. We may, however, be perfectly assured that he had reasons, and most excellent ones, and a little study of these may be interesting and profitable.

In the process of the development of mankind there has been noticeable a constantly increasing tendency toward differentiation and specialization, each step in the process being a slow one, and, as a rule, taken at first by some man or group of men trained in some other line. In this way have come about many new forms or fields of work, each adapted more or less from others of a previous and perhaps lesser civilization. Each new profession, or branch from an older one, demanded and received a new cognomen. This process of differentiation has developed more or less clearly defined groups of men, as, for example, the professions of the ministry, medicine, law, civil engineering, architecture and so on.

Fifty years ago, when Mr. Olmsted began this landscape work, there was beginning to be a demand in this country for men to do a certain line of work that was intrinsically quite different from that previously carried on by either the architect, the engineer or the gardener, and yet work that embodied some of the principles here-

tofore utilized by all of these men. Here was this great tract of land, now known as Central Park, to be developed and made beautiful, for the purpose of providing the crowded millions of the great city of the future with the opportunity "for a form of recreation to be obtained only through the influence of pleasing natural scenery upon the sensibilities of those quietly contemplating it." This was a new problem for this country, and indeed for any country, for none of the great parks in Europe now utilized for this purpose were originally created for anything of this sort. They are chiefly the result of developing land that had originally been set aside as hunting forests by the great nobles or rulers of Europe.

I think it will be generally conceded that New York was most fortunate in its selection of the master mind to work out this problem, and that the work of creating Central Park has been most successfully designed and executed. Mr. Olmsted saw clearly the greatness of the task and the differentiation of this form of design from that of the architect or engineer and certainly from the work of the gardener. He chose to call himself a landscape architect. Let us, therefore, look into the meaning of these words and see whether they are not well selected and worthy of our respect and of more general adoption.

That most delightful and interesting writer, Philip Gilbert Hamerton, says of landscape: "We use the word in two distinct senses—a general and a particular. In the general sense the word 'landscape,' without the article, means the visible material world—all that can be seen on the surface of the earth by a man who is himself upon the surface; and in the special sense 'a landscape' means a piece of the earth's surface that can be seen at once, and it is always understood that this piece will have a certain artistic unity or suggestion of unity in itself"; and further he adds, "although the word refers to the natural land, it does not exclude any human works that are upon the land." The word is derived from two good Anglo-Saxon parts, "land" and the suffix "scape," corresponding to "skip" or "ship," as in the word "friendship," meaning "the state or condition of being." Landscape then means "the state or condition of being land." When we come to add the word architecture, however, the connotation conveys to many people a wrong impression, but it should not, for in its early and primitive meaning the word architect meant simply and solely "chief workman" or "master artisan." It is well, I believe, for us to recall this earlier meaning of the word at the present time.

It is quite largely the architect himself who is responsible for any wrong impression that may have developed in the use of the

term landscape architect; as many have assumed that, because the word architect is used at all, the term landscape architect means simply an architect who meddles a bit with the landscape immediately surrounding his buildings. Many architects have done this, with regrettable results both to the client and to the profession of landscape architecture. I think it is but fair to suggest that, if the architect solves the problems of his buildings successfully, he may well leave to the landscape architect the matter of designing the surroundings for them, realizing that his own architectural problems are many and difficult, and that the trained landscape architect can, by co-operating with him, greatly improve the net result; for, as we all know, the effect of many a successful building has been seriously impaired by lack of a proper setting.

What Mr. Olmsted meant when he termed himself a landscape architect was that he was aiming to be a master artisan in matters pertaining to land, having regard both to the beauty of its appearance and to its use. In a very real sense such work covers agriculture, forestry, gardening, engineering and the elements of architecture.

Landscape architecture has been defined as "a group of activities which include horticulture, architecture, civil engineering and agriculture." Humphrey Repton, a great English authority on matters of this sort, says that in order to carry out this line of work one must possess not only artistic ability and taste, but "a complete knowledge of surveying, mechanics, hydraulics, botany and the general principles of architecture." We may well weigh his words, for Humphrey Repton was a cultivated English gentleman of great refinement and good taste. He was the first Englishman from such a grade of society to undertake the planning or designing of country estates. Kent, one of his predecessors in this line of work, was a coach painter by trade, who possessed some artistic taste, but little culture. "Capability" Brown, Repton's most famous immediate predecessor, was a gardener, who, by association with men of refinement and by his tact and native ability, worked his way up to an honorable place; but Repton was a well-educated English gentleman, who had traveled and studied much. Repton, however, called himself a landscape gardener, as did all of the others at that time, but Mr. Olmsted chose to avoid that term for several reasons. In the first place, these workers in landscape design in England had confined their efforts almost entirely to the design of country estates. The term landscape gardening was, I believe, first used by the poet Shenstone to mean more particularly an informal or picturesque treatment of the grounds of an estate, as distinguished from the

older style of formal treatment that had been in vogue and which had been carried to such excess. In the early part of the eighteenth century formality had been carried to the point of puerility. A reaction set in, due to numerous causes, and the "new style," or so-called "English style," was introduced by Kent and others, who, as Sir Horace Walpole enthusiastically exclaimed, "leaped the wall and saw all nature was a garden," and so in fact it is in those delightful parts of old England in which they labored; those country estates with their deer parks and pleasure grounds. These men made a practice of designing country places in an informal or naturalistic manner, and termed this landscape gardening. They were in favor of abolishing all formality, and they themselves carried their theory to excess.

Later, in the latter part of the eighteenth century and the first of the nineteenth century, men like Repton came forward, realizing that formality had its place and value, and began to use it under certain circumstances, but still called themselves landscape gardeners. This latter use of the term was a serious twisting of the original meaning; for a garden is, properly speaking, a place engirt, inclosed or set apart and highly cultivated. Landscape is, as we have seen, a piece of the earth's surface that can be seen at one time by a man who is himself standing upon the earth, and may, of course, mean a broad stretch of country not at all inclosed.

There is another important point and one that has not been particularly mentioned in discussions of the term landscape architect, one that I have already alluded to, namely, that these English landscape designers were engaged almost exclusively in the preparation of plans for country estates. These were, of course, not always large, and often were walled in or engirt, and, therefore, perhaps in a sense gardens. Mr. Olmsted, in 1856, had before him not such a problem, but that of designing a great public park for a large city. This work was not gardening in any sense of the word; it was something quite different. It was a work of design, a work that could be undertaken and successfully carried out only by a "master artisan in matters pertaining to land." Here were to be developed, and we know how well it has been done, broad peaceful landscape effects, giving the tired city dweller opportunity for restful contemplation and relief from city sights and sounds. These were to be designed and executed where none had existed before, and in such a way that there should be no obtrusive evidence of man's elaborate control and no marring of the pleasing, restful effect by such garden elements as beds of geraniums or rare and striking shrubs clipped into formal shapes; in other words, no gardening. This was

what he termed landscape architecture. The French landscape designers had already adopted this term, their phrase, architecte paysagiste, meaning simply landscape architect.

Many of Mr. Olmsted's great works are familiar to us all. They include Central Park, New York; Prospect Park, Brooklyn; the almost unrivaled Park System of Boston; the great work designed by him at the World's Fair at Chicago; and almost innumerable country estates, notably Biltmore, at Asheville, N. C., the mere enumeration of which serves to show some of the diversity of the work, and even the most casual observer can see in them some of the reasons why this sort of work is not properly to be called landscape gardening. A gardener, as commonly understood, is one who cultivates a garden. He may, and of course should, know a great deal about botany and horticulture, but when you come to associate the word garden with landscape there is implied simply that we have a gardener who cares for a garden having a naturalistic or landscape character; the absolutely essential factor of creative design disappears. Expensive mistakes have often resulted from employing on landscape work a person who was simply a common gardener and ignorant of the principles of this sort of design. Art commissioners would not think of employing a man to design a monumental public library or city hall simply because he was a good stonemason.

Landscape architecture is then, as Charles Eliot, one of Mr. Olmsted's gifted disciples, has well said, "the art of arranging land for use and the accompanying landscape for enjoyment." Landscape gardening is, it seems to me, a term conveying in itself confused ideas, but used, if at all properly, simply to cover that part of the landscape architect's work which has to do with the development of formal or natural beauty by the simple process of removing or setting out and caring for plants. This is quite secondary to the matter of designing a general scheme for the development of land for any given purpose.

The problems with which a landscape architect has to deal are many and varied. Among them are, as we have seen, the design for a great country park for a large city, where the object is, or should be, to afford perfect relief and rest to the tired citizen by offering to him and preserving for him the contrast of broad, restful rural scenery unmarred by any of the sights and sounds of city life. This is a great problem, involving many considerations as to choice of the tract of land, its bounds, its present scenic effects, its accessibility, the design of roads and paths through it, so that the public may enjoy, but not destroy, its beauties. Fig. 1 shows some of the

Fig. 1. View in part of Boston's Park System.

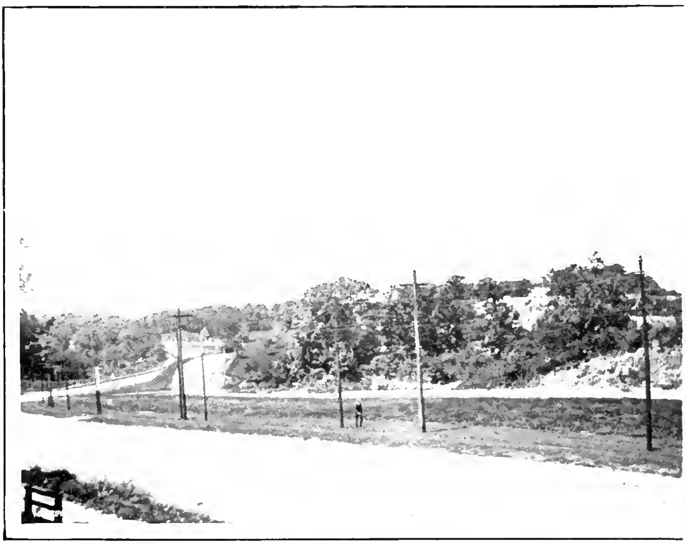


Fig. 2. View of portion of Commonwealth Avenue, a part of Boston's Boulevard System.

Figs. 3 and 4. Views on the Riverway, a part of Boston's Parkway System leading to Franklin Park.

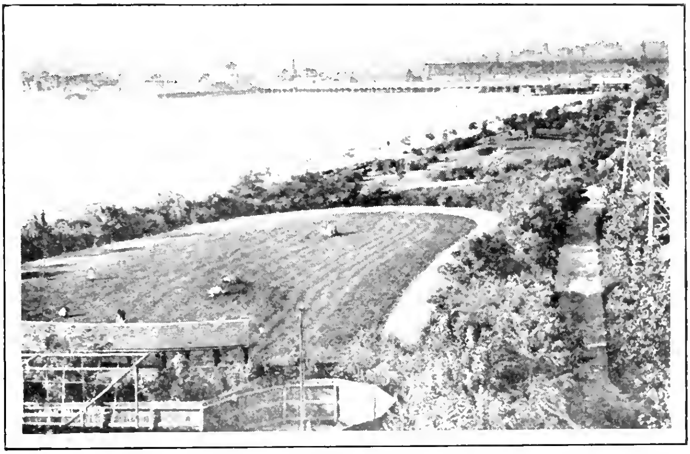


FIG. 5. CHARLESBANK PLAYGROUND, BOSTON.

FIG. 6. A COUNTRY ESTATE NEAR BOSTON.

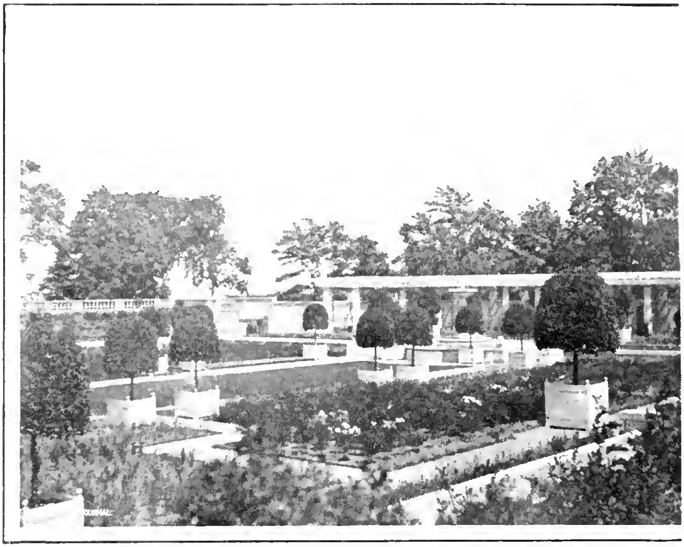


Fig. 7. An American-Italian Garden.

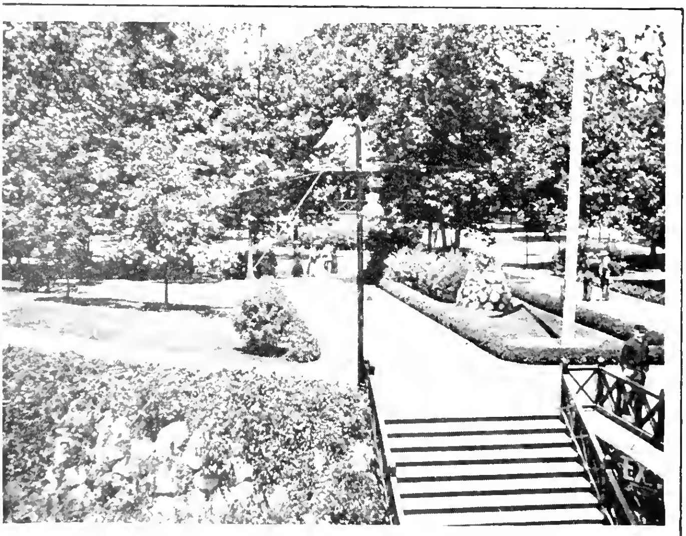


Fig. 8. Part of a Street Railway Company's Amusement Park.

pleasing, restful results of landscape design, being a view in part of Boston's Park System, and, of course, only one of many which might be given to illustrate this part of the landscape architect's work.

Then there are approaches to the park, "parkways" so called, to be designed, involving much careful thought as to location and details of grades (Fig. 2). Perhaps a hitherto neglected sluggish stream, whose banks had been an unsightly dumping ground, can be transformed, by careful design, into a beautiful parkway.

Figs. 3 and 4 are scenes of what is known as the "Riverway," a part of Boston's Parkway System, leading from the city proper to Franklin Park, and are especially good examples of landscape design; for, beautiful and natural as they now appear, there is hardly a line or bit of vegetation, except the older trees, that has not been placed by the hand of man where we now see it. Fifteen years ago this part of the town was one of the ugliest sites imaginable. A brackish stream struggled along through tangled masses of sedges and swamp land. Now all is beauty of the most restful sort, but every particle of it is the result of design. This is not landscape gardening, but landscape architecture, the work of a "master artisan in matters pertaining to land."

Other problems for the landscape architect are the planning of the more or less formal paths and planting of the City Square; the development, in a pleasing way, of the children's playground (Fig. 5); or the surroundings of the schoolhouse, with its school garden, now so necessary an adjunct to American educational methods. Then, too, the stately Public Library or City Hall must have its appropriate landscape setting.

The landscape architect should share with the architect the design of country estates and homes (Fig. 6), the two working together to place the house and the buildings properly as regards terraces, approach roads and paths, the landscape architect using his trained taste and experience in working out appropriate changes in the surrounding scenery, perhaps screening, by judiciously placed planting, an unsightly neighboring building. There may be a formal garden to design, with its paths, ramps, terraces and pergolas (Fig. 7).

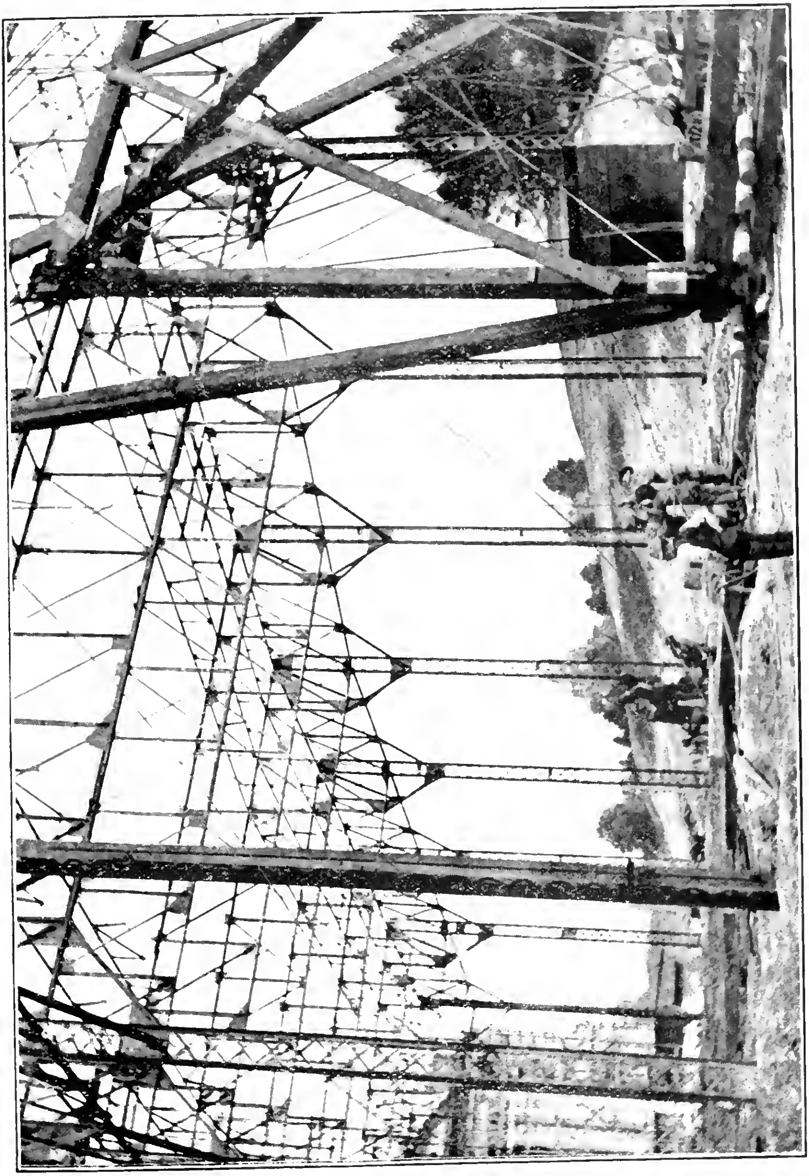
Then there is the important subject of the design for naturalistic treatment of reservoir basins. This is a most important class of work, and one in which the engineer can effectually co-operate with the landscape architect. I can but allude to this matter very briefly, but the results of this branch of landscape design certainly add greatly to the beauty of such basins, and, by the pleasing naturalis-

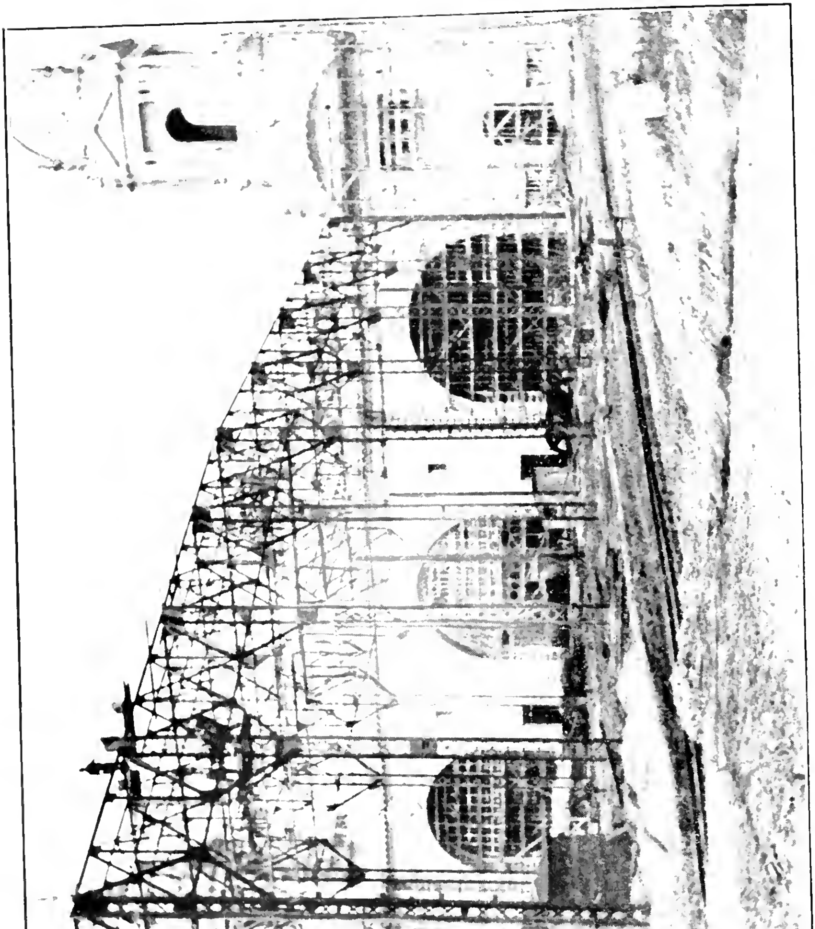
tic treatment of shore line and embankment, make them beautiful lakes rather than stiff and ugly artificial reservoirs. An entire lecture might well be devoted to this branch of the subject, and the superiority of such naturalistic treatment over the former mathematical regularity or partial formality of the more common mode of treatment of such basins can be clearly shown, and I trust those of you who have such problems to solve will remember the importance of looking at them in this way and of co-operating with the landscape architect in obtaining such desirable results.

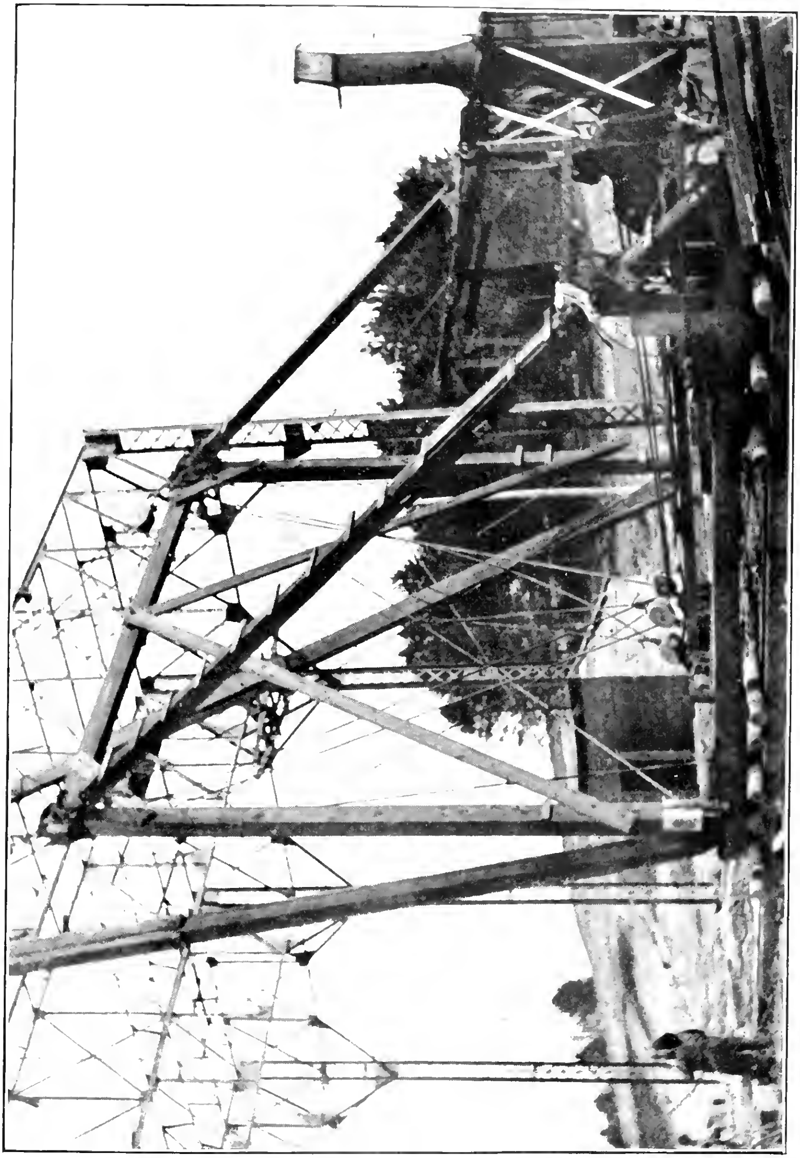
There is also the question of designing, for the street railway companies, amusement parks for their thousands of patrons (Fig. 8). In this case provision must be made for the necessary band stand, open-air theater and other amusement features, and great care must be exercised in securing ample approaches and the like.

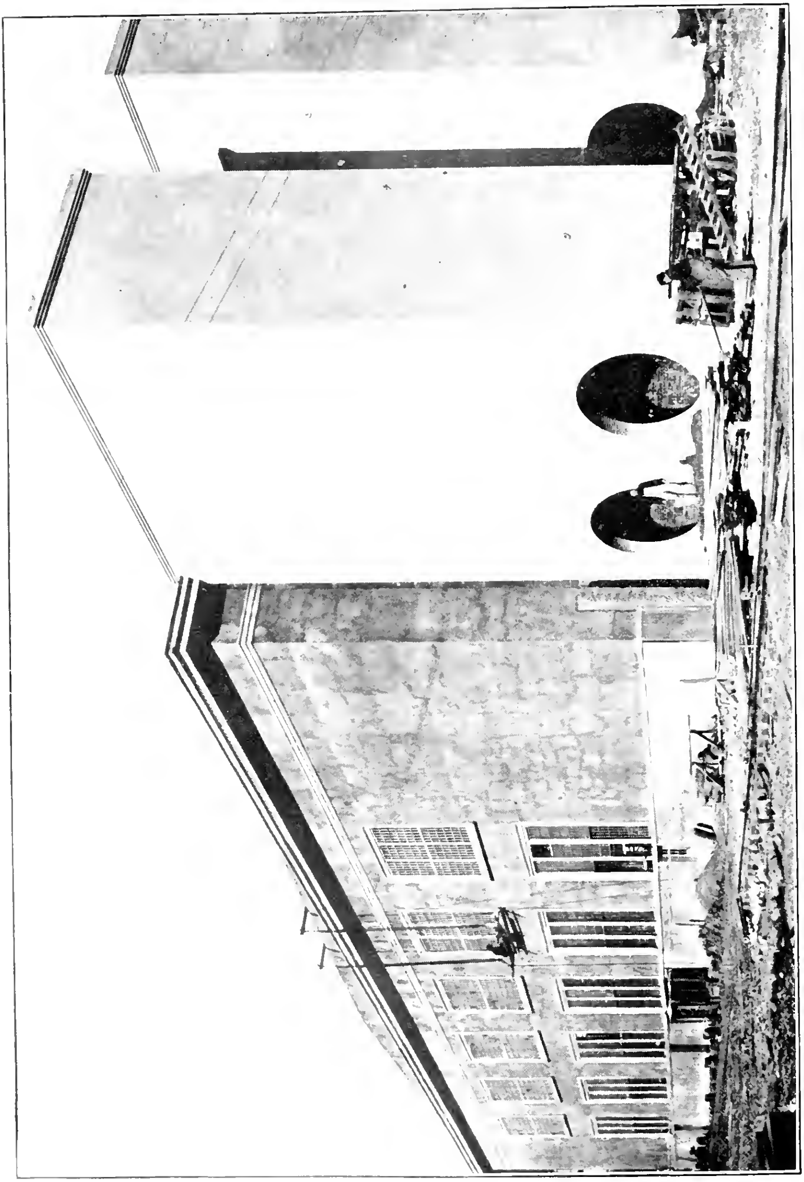
There is much for the landscape architect to do in the laying out of new suburbs for our growing cities, residential parks, neighborhoods of summer cottages at the mountains or the seashore, and there are the grounds of hospitals, educational and other institutions, of hotels and railroad stations, to be designed.

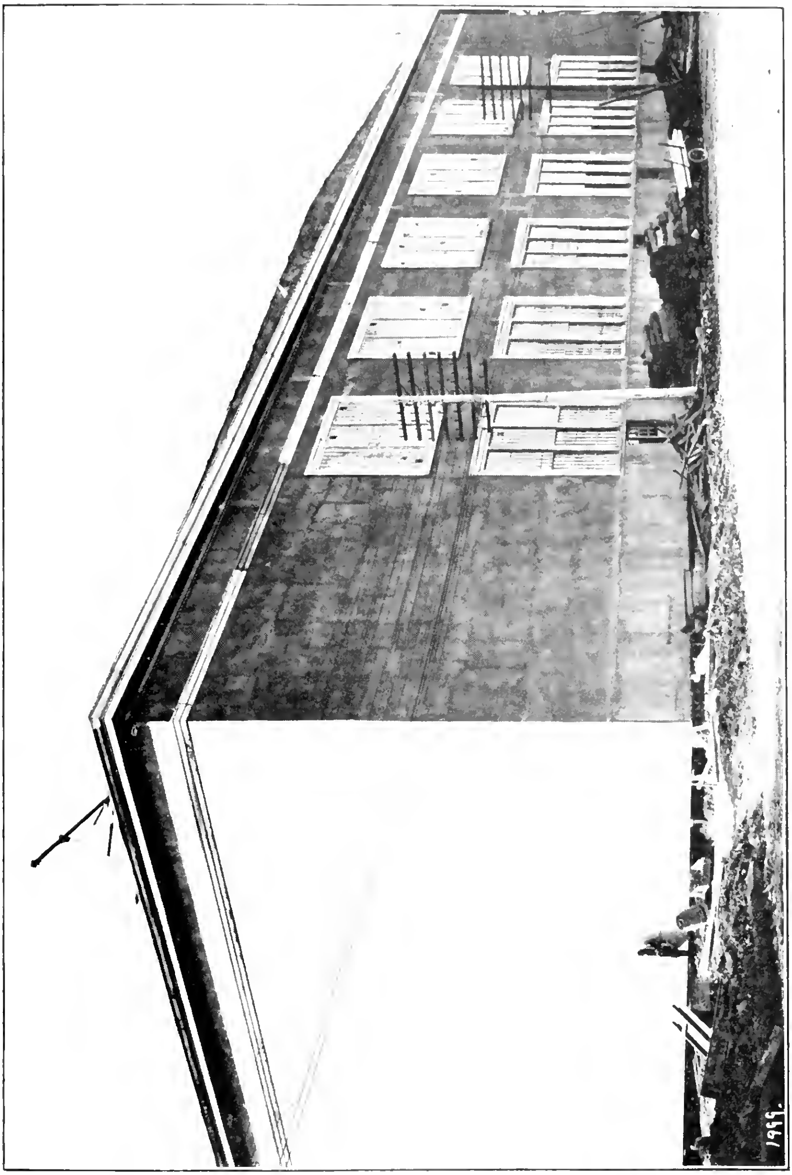
In the time at my disposal it is impossible to more than briefly touch upon the many and varied fields of work open to the landscape architect or to explain more fully the principles involved in such design. I can only add that all of these problems involve the thoughtful care of trained minds, and in all of them the first and fundamental purpose should be to ascertain, by careful study of the existing natural conditions, what the "genius of the place" really is, what it is that nature herself hints at, and then, by taste and judgment, to so design the improvements that they will harmonize with the natural tendencies of the place, and be both practical and useful, always remembering what Charles Eliot has so wisely said, that "what would be fair must first be fit."

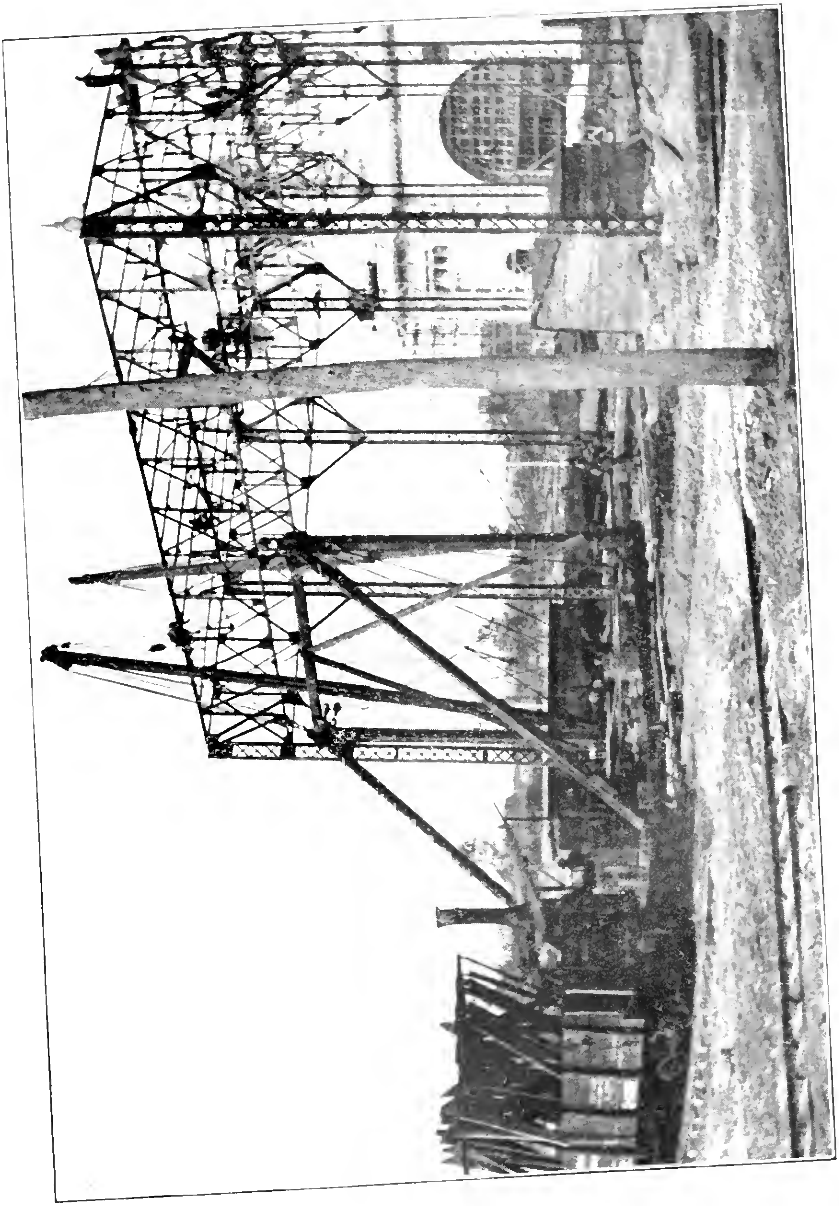


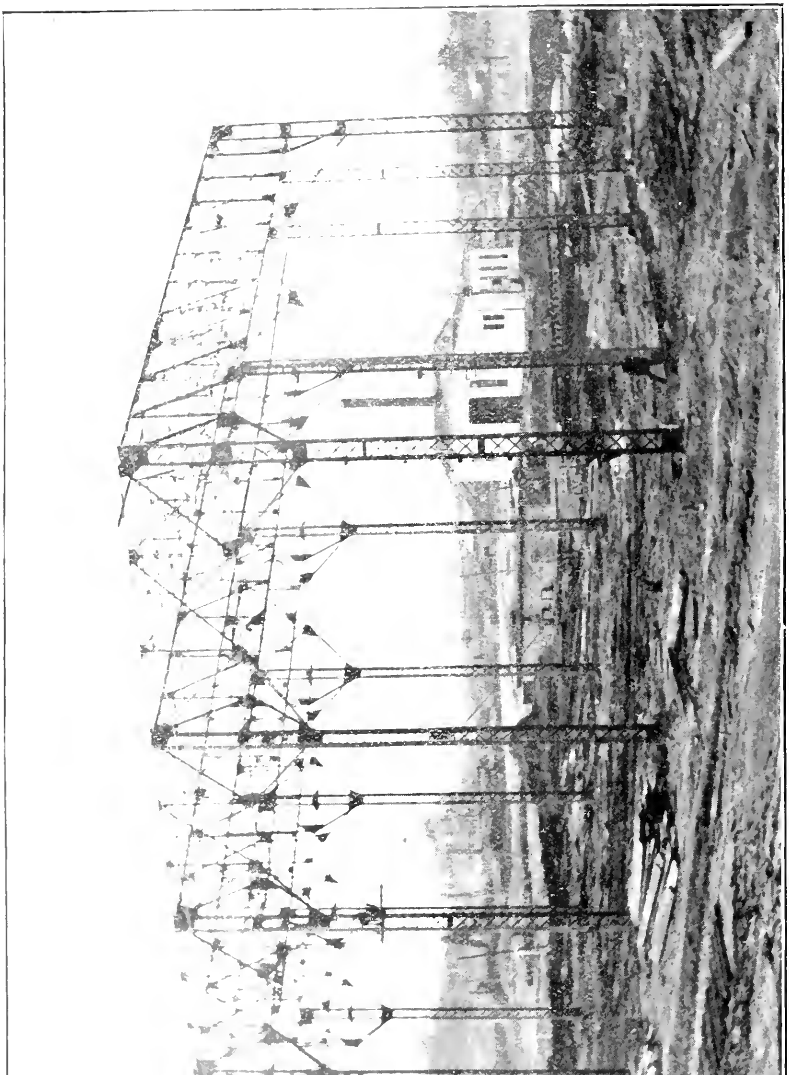












"SUGGESTIONS FOR STEEL-CONCRETE CONSTRUCTION."

By John C. Anderson, Member of the Louisiana Engineering Society.

[Read before the Society, April 9, 1904.*]

In taking this topic for discussion to-night, I am aware of my own limitations in dealing with such a subject. In the first place, such construction is really only in its infancy in America, and very few of us have had access to reliable translations of the writings of those French engineers who have put the results of their studies on paper. In the second place, the more one has to do with concrete construction—and particularly with construction wherein there is an attempt made to scientifically combine steel and concrete to the end that these materials shall act together and in a way to produce the best results—the more one learns to avoid dogmatism.

I shall, therefore, attempt to set before you only a few of the generalities which I conceive to be fundamental, together with an application of steel-concrete construction which I deem particularly adapted to use in this vicinity. It is my intention to treat the matter from a practical rather than from a technical standpoint.

In the very beginning of this discussion it is well to study the working qualities of both steel and concrete separately, before we consider them in their combined relation.

We note, then, that it is easy to ascertain the strength of a given quality of steel; and, but for one factor, it would be equally easy to find the strength of concrete, and that factor is the mixing. The manufacture of steel has reached the stage where, with given chemical properties, the physical properties are almost absolutely known. The same is true of concrete, but, when the cement is combined with the aggregate, the "personal equation" enters so largely into the mixing that we are at once confronted with the fact that, in most cases of actual construction, the strength of the concrete is largely indeterminate.

This brings me up to what I consider the most important rule in concrete construction—a rule which I evolved for my own use, and which I present for your consideration. It is: "Never use concrete in such a manner that, if portions are found defective, they cannot be removed and replaced without endangering the stability of the structure, unless the concrete can be mixed and placed in position under the eye of an experienced engineer."

* Manuscript received May 18, 1904.—Secretary, Ass'n of Eng. Socs.

It is well said that "every rule has its exceptions." The exception I habitually make to the above rule is in the consideration of larger masses (such as bridge piers), where the inferior strength of portions of the work will not affect its usefulness, even though such defective portions are not removable.

Having noticed the relative certainty with which we may calculate on the two materials in our designing, let us proceed to the consideration of their use in conjunction.

The first point of interest, to an observer of their united action, is the firmness with which cement mortar adheres to steel. So close, indeed, is this adhesion, that I am almost inclined to regard it as a fusion rather than an adhesion. The affinity is such that there is a stronger bond between the mortar and the steel than there is between the mortar and the materials usually composing the aggregate. This has been demonstrated to me on a number of occasions, both by experiment and in actual construction. No doubt many of you have had occasion to cut the concrete away from a steel beam, and have noticed that the chisel would cut into the beam but would not cause the concrete to "flake off," which would have been the case but for the close adhesion of which I speak.

A second point, which we will do well to note, is the fact that steel and concrete have practically the same coefficient for expansion by heat. This fact enables us to proceed with confidence in the design of structures which will be subjected to variations of temperature.

The only other general point to which I would call your attention is the well-known fact that steel develops its greatest strength when in tension, while the greatest strength of concrete is developed under compression; and this is equally true when they are used together.

Time permitting, it would doubtless be of interest to take up such points as the rust-preventive qualities of cement mortar in contact with steel, the study of concrete as a non-conductor of heat and as a preventive of electrolysis, etc., but I must hasten to suggest what I consider the most practical application of steel-concrete construction to local conditions. This I believe to be the steel-concrete wall.

The peculiar soil of New Orleans and vicinity compels the engineer, when called upon to design a structure, to avoid, as much as possible, all heavy construction. In spite of this condition, I notice that, instead of using concrete, there are continually being built brick walls when a concrete wall would answer every purpose. Take, for example, a power house. We will say that the building

is 50 feet wide and 80 feet long, and that the walls are 30 feet high to the eaves. In brick construction this wall would be 22 inches thick, and the weight of the walls would therefore be about 800 tons. The same walls, of steel-concrete construction, could be built 6 inches thick. By supporting the roof on steel columns encased in concrete pilasters, equally good results would be obtained. The weight on the foundations would be 240 tons instead of 800 tons, and the cost to the owner would be about 10 per cent. less.

As an example of this sort of wall, I will call your attention to the boiler house at the Louisiana Purchase Exposition, St. Louis, Mo., which I assisted in designing. This building is about 200 feet by 300 feet, and the walls have a clear height of 40 feet from the floor to the bottom chord of the trusses. The steel columns are 20 feet apart, and the walls are built of cinder-concrete, reinforced with steel angles, channels and rods, and are but 6 inches thick. I present, for your inspection, some photographs showing the building during the erection of the steel work and others after the concrete wall was in place. These photographs were taken before the finish was applied to the exterior, and hence the rough appearance of the walls.

THE PURIFICATION OF WATER.

By Prof. John M. Ordway, Member of the Louisiana Engineering Society.

[Read before the Society, March 14, 1904.*]

Of the waters that are most readily available for use in the house or the factory, many fall short of a desirable degree of purity. Some contain suspended matter, some hold in solution salts of calcium, magnesium or iron, some are charged with colored or colorless organic substances as well as microscopic living organisms, and some have, at times, a slightly unpleasant odor or taste.

The coarse particles of solid matter, carried along by streams, are easily removed by filtration through sand; and the filter not infrequently takes out, from an apparently passable water, an astonishing amount of dirt. Indeed, leaving freshets out of account, there are very few rivers which are at all other times clear enough.

By very numerous experiments, made for the Massachusetts State Board of Health, it has been found that over 99 per cent. of the bacteria and other organisms which abound in surface waters may be removed by sand filtration. To be sure, most species of bacteria, diatoms, desmids and infusoria are not known to be harmful. Still, in thickly settled regions, typhoid and other disease-producing microbes are occasionally present in the water; and there are a few kinds of diatoms and infusoria which at times multiply inordinately and give the water a disagreeable odor or taste; so, on account of the occasional, unexpected occurrence of bad organisms, it is well to filter out all the removable living things. But when long enduring turbidity is caused by fine clay, it requires a filter of peculiar texture to do thorough work. A soft, porous earthenware burned at a moderate heat, appears to afford the most efficient apparatus. Thus, our very refractory Mississippi River water comes perfectly clear through an ordinary clay flower pot, though without pressure the rate is slow; such a pot, having an inner surface of 148 square inches, yielding 300 cubic centimeters in 24 hours.

There is now in the market a filter of similar material, called the "Lynn Filter," which, with a moderate pressure, does wonderfully well both as to quality and quantity. It consists of a hollow earthenware cylinder, arranged vertically in a strong cast-iron case, so that the turbid water has access to the inner and outer surfaces of the cylinder. Between these surfaces are many vertical tubular

* Manuscript received May 18, 1904.—Secretary, Ass'n of Eng. Socs.

passages, which receive the clear water and convey it to the outlet pipe at top. The mud is shaved off, from time to time, by bronze scrapers pushed hard by springs against the cylinder surfaces. These scrapers are set in frames, which are revolved by an outside crank with suitable gearing. The earthen cylinder, from which the piece shown was taken, was 15 inches in diameter on the inside, and 20 inches outside, and 29 inches long. The area of the cylinder surfaces was therefore 22 square feet. There were 32 tubular spaces in the wall, each $\frac{7}{8}$ inch in diameter, making an area of 17.7 square feet. The material is very soft, the necessarily frequent scrapings wear away the surfaces pretty fast, and, unless the springs are nicely adjusted, the wear is not uniform. So the cylinders, as well as the scrapers, must be replaced occasionally. The machine is expensive and requires careful management. Still, in some cases, it may be advisable to treat the Mississippi water in this way rather than by the coagulation method.

Color.—Many ponds, brooks and rivers are tinged, more or less, with organic matter derived from the soils which they drain. This brown matter, which goes under the general name of humic acid, is probably brought into solution by an exceedingly small amount of potash or soda, furnished by the gradual decomposition of the rock particles of the soil. It seems to be harmless, though it gives the water an unpleasant appearance.

The artesian water of our city, as seen at Tulane University, the Young Men's Gymnastic Club, the Central Power Station, and other localities, is very highly colored; and it may well be, for it contains about 37 parts of sodium carbonate to 100,000, and decayed vegetable remains abound in the depths of our delta.

But this water, bad looking as it is, can be completely decolorized in a few minutes by adding bibasic or tribasic aluminum chloride. Humic acid has a stronger affinity for alumina than for soda, and therefore a flocculent precipitate of aluminum humate is formed and rapidly subsides. Some costly attempts to clear this water by the use of alum and filtration have failed of success, because no skillful pains were taken to find out the exact amount of coagulant required. It is not a case of mere entanglement, but a definite chemical combination is to be formed, so that a certain amount of the base is needed, in order that it may unite with the whole of the humic acid present. With less alumina the precipitation is incomplete. It is really very easy, by a few intelligently conducted trials, to determine the proper quantity of the aluminum salt.

For decolorizing brown waters, the highly basic chloride of aluminum is much better than the ordinary sulphate, as it acts more

quickly; and, the needed alumina being combined with only one-half or one-third as much acid, much less alkali in the water will suffice to take up this acid and turn over the alumina to the undisputed possession of the humic acid. I have tried many surface waters of New England, Canada and Colorado, including the Connecticut, Merrimac and Androscoggin Rivers, and found that some forty of them were cleared by half a drop, a drop, or, in one or two instances, two drops of a 13 per cent. solution of the tribasic chloride to a liter of water. When the color is very faint, it takes several hours for the precipitate to gather and settle.

Iron.—Iron may be present in water as ferrous carbonate or sulphate. Of the carbonate we have a good instance here in New Orleans in the salt water of the deeper artesian well at the Young Men's Gymnastic Club. This water is perfectly clear and colorless as it comes from the ground, but in a very few minutes it becomes opaline, and after long exposure to the air it deposits the iron as insoluble ferric oxide. In the first method of fitting the water for bathing, we pumped it into 2 very large cisterns, and, after adding very small quantities of lime and aluminum sulphate, blew air through it for an hour or more. Then in a few hours it settled perfectly and permanently clear.

In a plan afterward adopted, the crude water was simply showered through the air in a very much broken fall, and then filtered through sand.

So, when iron is not obstinately held in solution by organic matter, we may readily bring about the change to insoluble peroxide by forcing air through the water, or by a much retarded dropping of the water through the air. The addition of a little lime or soda facilitates the oxidation. Such an addition is particularly needed when ferrous sulphate is present, since this salt is changed very slowly by the air, but when the stronger acid is taken up by an alkali there is formed ferrous oxide, which is very greedy of oxygen.

Hardness.—But the most common and most troublesome fault is the presence of lime and magnesia salts, which cause a harsh feeling in washing with soap, because they form sticky oleostearates of calcium and magnesium. We therefore call such waters "hard." The water of the Great Lakes and of the St. Lawrence River, which drains them, and that of most of our Western and Southern streams, is unpleasantly hard. In analyzing the Mississippi River water every week for a year, I found an average of 6.95 parts of calcium carbonate and 1.9 parts of magnesium carbonate in 100,000 parts of the settled water. The maximum amount of the

two together was 13.66, and the minimum 6.86. In a former paper on the water supply of New Orleans, I stated that the Mississippi River water contains carbonate of sodium. Later experiments have led me to believe that the sodium is present only as sulphate and chloride. The mud also contains some of the same substances.

After considering the best way to get rid of the mud, it seemed very desirable to go farther and find some feasible means of eliminating the soap-killing impurities. I have, therefore, made numerous experiments with such possible precipitants as are cheap enough and safe.

When we wish to know just what is thrown down by any chemical in a gradatory series of experiments, it is, of course, necessary to collect and analyze the precipitates—a work requiring much time and patience. But a ready means of forming a judgment as to the comparative efficiency of the trials is afforded by Clark's soap test, which consists in adding, to 100 cubic centimeters of the treated water, a standard solution of soap, a little at a time, till, on thorough shaking, a permanent foam remains on the surface. According to the French mode of reckoning, which is preferable to the English or German, the number of degrees of hardness is supposed to represent the number of grams of calcium carbonate in 100,000 c.c. of the water. The method does not admit of great precision, but it serves well for comparisons.

To give some idea of the possible ranges, I may state some of the results which I have obtained while going about during the summer vacations. The best of the waters tried was that of Peabody River at Gorham, N. H., a small stream a few miles long, which takes its rise among the highest of the White Mountains, where granite constitutes the geological formation. The hardness was much less than 1 degree. The water supply of Colorado Springs, coming from streams among the Rocky Mountains, had a hardness of somewhat less than 1 degree. Boston water, taken from the Chestnut Hill reservoir, showed 1.2 degrees, the same as the water supply of Quebec. That of Buffalo, N. Y., which comes from Lake Erie, stood at 7.6 degrees. The River St. Lawrence, at Montreal, gave 8.2 degrees. What was in use at St. Louis last July tested 9 degrees. At Denver, the average of two trials, a week apart, was 9.5 degrees.

Remarkable differences, within a moderate compass, were shown at a place among the Green Mountains, in a mica slate formation. A well on the high ridge of Randolph Centre showed a hardness of 21 degrees. Another well, some 80 rods away, tested 15 de-

grees. A copious spring, about 200 rods from the latter, and some 300 or 400 feet lower, showed 9.5 degrees.

In working with our river water, in order to have a stock of uniform composition and free from the interference of suspended clay, about 70 gallons of the crude water were run into a galvanized iron tank, and cleared by treatment with bibasic chloride of aluminum and iron. This was done last November, when the water contained about the maximum of dissolved impurities.

Two or four liters of clarified water were taken for each trial. Of the precipitants, the limewater contained 1 gram of lime in about 800. Of the others, normal solutions were made, like those used in volumetric analysis. That is, the soda salts, for instance, had 23 parts of sodium to a liter.

Lime.—Water which contains calcium and magnesium carbonates held in solution by carbonic acid may be partially purified by treating it with just enough limewater or milk of lime to combine with the excess of carbonic acid. The lime added is all precipitated, and with it a part of the carbonates originally present. As lime is a stronger base than magnesia, it may be expected to decompose the magnesium salts, and set the base free, but of the calcium compounds it can affect only the bicarbonate.

In my clarified water, one-fifth of the calcium carbonate had been changed to chloride by the coagulant used. About three-fifths of the remaining carbonate and one-sixth of the magnesia were thrown down by an optimum of 50 c.c. of limewater to a liter. The hardness was reduced from 10 degrees to 6.5 degrees.

With the softer water of February, cleared by the Lynn Filter, an optimum of 70 c.c. of limewater to a liter reduced the hardness from 7.5 degrees to 4.5 degrees.

So lime makes an improvement, but does not carry the softening quite far enough. Lime acts slowly, but the precipitation is completed in 24 hours.

Carbonate of Sodium.—When calcium sulphate is the offending substance—and it occurs in a great many waters—soda ash is a very suitable purifier, as it decomposes gypsum and leaves in solution harmless sodium sulphate, calcium carbonate being thrown down. But I hardly expected sodium carbonate to have any effect on calcium bicarbonate. In fact, however, it has a pretty strong affinity for carbonic acid, and when it was put into the clarified water it made no show for some time, though in a day or two there appeared a granular coating on the sides and bottom of the containing vessel. The maximum effect was produced by 6 c.c. of the nor-

mal soda solution to a liter, which precipitated most of the lime and reduced the hardness from 10 degrees to 4.5 degrees.

Carbonate of sodium, then, is slow in its action, and is somewhat lacking in efficiency.

Trisodic Phosphate.—This salt, which is made by combining caustic soda with the ordinary disodic phosphate, works much better than the carbonate, but it is somewhat more expensive. It precipitates both lime and magnesia as flocculent, somewhat gelatinous phosphates which settle readily.

In the clarified water of November, 6 c.c. of the normal solution threw down nearly three-fourths of the 2 carbonates, and brought the hardness down to 3.4 degrees.

From the softer water of last April, 6 c.c. took out nearly all the lime and magnesia and lowered the hardness to 1.6 degrees.

Caustic Soda.—Caustic soda proved to be the most effective of all the single purifiers. The precipitate formed by it is of a slightly gelatinous character, and is deposited in a few hours. The maximum effect on the clarified water was produced by 6 c.c. to a liter. By this amount nearly all the lime and magnesia were taken out and the hardness became less than 1 degree. With 5 c.c. to a liter, the hardness was diminished to 1.8 degrees, and this is soft enough for any use. The same quantities gave almost as good results with crude river water.

The precipitate produced by the caustic soda has some entrapping power, so that this alkali tends to clarify, as well as soften, the turbid water. But the gelatinous calcium and magnesium phosphates take a stronger hold on the fine clay, and hence the caustic operates more quickly when it has some trisodic phosphate mixed with it.

The turbid water, with 4 c.c. of caustic soda and 2 c.c. of the phosphate added to every liter, deposited the mud very quickly and became quite clear in less than 24 hours. Its hardness was then only 1.8 degrees.

For mere clarification, this alkaline coagulant cannot compete with aluminum and ferric salts, because a much larger quantity is required, and besides, if there is any organic matter present, a little more of it is left in solution. But for clearing and softening we may advantageously use both, putting in the soda mixture first and the aluminum or ferric salt awhile afterward, and leaving the water so treated 24 hours to settle.

Aluminate of Sodium.—As alumina is best for entrapping the mud, while soda is best for softening, it was thought that aluminate of sodium, which can be made very cheaply, might be the ideal

purifier. It was found to do the work, indeed, but altogether too slowly.

Double Oxalate of Sodium and Aluminum.—As in chemical analysis we find an oxalate to be the best precipitant of lime, it seemed that the oxalate of aluminum and sodium might produce the desirable double effect. But here again too much time is required for completing the reactions and settling. Moreover, the cost would be somewhat higher than that of the other articles mentioned.*

At first thought it seemed strange that, in order to effect the maximum amount of precipitation, there should be required an excess of the precipitant of one-half or more over and above what theory calls for. But, in such exceedingly weak solutions as the water under consideration, the salts are more or less dissociated into their constituents, and to counteract this there must be an excess, in some cases of the basic, and in others of the acid ingredient. Thus, in analytical work, to bring about a complete formation and precipitation of ammonio-phosphate of magnesium, we must use a considerable excess of ammonia; and, in trying our water with oxalic acid, it was found that 1.5 c.c. of the normal acid to a liter threw down about half of the lime, and reduced the hardness from 7.5 degrees to 3.7 degrees, while 3 c.c. increased the precipitate one-fifth, but was so much in excess as to carry the hardness up to 16 degrees.

Among the reagents used, only the lime, the alumina, the phosphoric acid and the oxalic acid are removed with the precipitates formed. The alkali of the sodium compounds remains in solution as bicarbonate, carbonate, and a little caustic. For most uses this small quantity of soda is unobjectionable, it being equivalent to not over 3 parts of sodium carbonate in 10,000, or 18 grains in a gallon. The alkalinity can be reduced by neutralizing one-third or one-half with any acid, after the water is settled and drawn off. But this complicates matters too much. Our artesian well water contains nearly 4 parts of sodium carbonate in 10,000, and this is certainly very good for steam boilers, at least.

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* I have not dwelt particularly on the various combinations of the different chemicals that may be made. But it is obvious that advantages may be gained by using more than one. Thus, some of the turbid water was treated with 25 c.c. of limewater and 2 c.c. of caustic soda to a liter, and after a time, 0.45 c.c. of the bibasic ferric-aluminous chloride were added. In 4 hours it became pretty clear, and the hardness was 2.1 degrees. Of course, when lime and soda are used, in place of soda alone, the cost is less, and the water is left soft enough and much less alkaline.

But everybody cannot have an artesian well; and yet everybody who uses steam ought to have water that is as good or better. If such is lacking, it is very important to consider how the deficiency may be remedied. When lime and magnesia are the chief impurities, they can be mostly eliminated at a moderate cost, and thus there will be effected a saving of fuel and a saving of boilers.

A great many preventives and remedies have been empirically proposed for boiler incrustation, not a few of them being worse than useless. I believe the only articles that are rationally advantageous are caustic soda and lime for waters charged with the earthy carbonates, sodium carbonate for those containing the sulphates or chlorides, and trisodic phosphate for such as are turbid; and they should be used so as to take out the obnoxious substances before the water goes to the boilers. Prevention is far better than cure. We find accounts of several forms of apparatus which have been devised for the continuous separation of the impurities. In the most feasible ones, the water, after receiving the precipitant, is forced upward, in a slow current, against a series of deflectors, which are expected to turn aside the precipitate and let the clear water pass on. Of course, the real efficiency of such contrivances can be determined only by careful experiments. But it takes some little time for the reaction of the chemicals to be completed, and we should be surer of the best results if we let the treated water remain at perfect rest for several hours. I should, therefore, much prefer two or more simple settling tanks of sufficient size to furnish a full supply when used alternately.

For work on a moderate scale, as for domestic use, vessels like the one that I had made for my experiments would afford very good service. This is a galvanized iron cylinder 2 feet in diameter and 3 feet high, with a conical bottom 9 inches deep. It should have been 12 inches deep. About 3 inches above the outlet of the inverted cone is soldered to the sides a brass cross bar, perforated to receive the pivot of a $\frac{3}{4}$-inch vertical shaft. The shaft at top passes through the fixed middle piece of the wooden cover, and a little above this is furnished with a crank turning horizontally. Just above the lower brass bar there is fastened a piece of 2 x 3-inch joist, cut so as to form two propeller blades. A little brisk turning of the crank mixes thoroughly the crude water and the chemicals. The clear water is drawn off by a faucet close to the bottom, and the mud can be run out by a cock at the apex of the cone. As it is not best to fill the cylinder higher than to within 2 inches of the top, we may reckon on a yield of about 33 inches or 65 gallons for one operation. When the river is but moderately

turbid, the mud needs to be disposed of only after the third or fourth filling.

Probably a tank, 3 feet in diameter and 3 feet deep, would be strong enough, if made of galvanized iron simply locked and soldered and wired at top. Such a one would give 145 gallons at a time. In very large apparatus the stirring would be done better by blowing in air at the bottom.

As it costs more to soften than to clarify water, we cannot expect the city water supply to be brought to the highest attainable excellence. Yet, when a coagulant is used, the addition of a little lime, to reduce the hardness somewhat, would not increase the expense very materially. But individuals could afford to complete the work on what they require for their own use. And there are cases in which it would not be unreasonable to demand, of those who serve the public, the fullest possible purification. Thus, in traveling on our Southern railroads, to one who is accustomed to clean and soft water, it is particularly disgusting to find the wash rooms of the sleeping cars provided with water that is both hard and turbid. Surely, we pay enough for accommodations to justify a call for something better.

When our city is supplied with clarified river water, will the present cumbrous cisterns be needed?

For washing or cooking, good rain water is certainly far better than the filtered river water. But the rain water, gathered from city roofs, is quite different from rain water among the granite hills; especially when, as has been the case here for some months past, heavy, cleansing showers are few and far between. Lately I have found the hardness of my cistern water at home to be over 3 degrees. It contains sulphate of calcium, derived, no doubt, from fine coal ashes and soot carried up chimney by the draught and dropped on the rough, slated roof. Still it causes no harsh feeling in washing with soap. We may perhaps consider 4 degrees the limit below which water begins to be passably soft.

Very likely many householders will continue to use their cisterns as long as they last; then, instead of renewal, they may find it better to set up more compact softening apparatus and be no longer dependent upon the unreliable clouds.

BOILER AND ENGINE TEST OF A SMALL STEAMBOAT.

By Warren Johnson, Member of the Louisiana Engineering Society.

[Read before the Society, April 11, 1904.*]

The following data and results were obtained from a short test of 2 hours and 42 minutes duration, and are not intended to represent the greatest power or efficiency, but merely the average dynamic conditions obtaining in the usual operations of this screw-propelling towboat when used in regular service without tow.

The run was on the Mississippi River, following, as nearly as practicable, the same course up and down stream, to eliminate the effect of the current; starting and ending at the same point. All distances were obtained from the Orleans Levee Board.

SIZES AND DIMENSIONS.

WOODEN HULL.

Length over all	45 ft.
Length between perpendiculars	40 ft.
Beam, molded	9 ft. 6 in.
Draft amidships, to bottom of planking	1 ft. 11 in.
Displacement	23,860 lbs.
Block coefficient	52½ per cent.
Wetted surface	380 sq. ft.

BOILER.

No. 7 Roberts Water Tube Boiler:

Grate area	8.67 sq. ft.
Heating surface	264.3 sq.ft.
Ratio of grate to heating surface	1 to 30.5.
Nominal horse power for a compound engine	41.2.
Height of stack above grate	12 ft. 9 in.
Area of stack	1.4 sq. ft.
Ratio between area of grate and stack	6.2.

ENGINE.

Compound engine, with cylinders 5½ x 10½ x 8-inch stroke.
Cut-off in high-pressure cylinder 9-16 stroke.
Cut-off in low-pressure cylinder 7/8 stroke.
Clearance, in both cylinders, ¼ in. at each end.

CONDENSER.

Surface condenser, with an external tube area of 130 sq. ft.
Length of run of water through tubes, 9 ft.
Ratio between boiler heating surface and condensing surface, 2.04 to 1.

* Manuscript received May 18, 1904.—Secretary, Ass'n of Eng. Socs.

PUMPS.

Combined simplex air and circulating pump, $4\frac{1}{2} \times 5\frac{1}{2} \times 6$.
Duplex feed pumps, $2 \times 1\frac{1}{8} \times 2\frac{3}{4}$ in.

PROPELLER.

Brass screw propeller, 32 in. diam., $3\frac{1}{2}$ ft. pitch, with total blade area of 3.6 sq. ft. on four blades.

Before starting, steam was raised to 100 pounds pressure, fires were drawn, and all water was pumped from condenser. When the boiler pressure had fallen to 40 pounds, fire was started anew with 27 pounds of yellow pine, and continued with Pittsburg coal, the analysis of which was given by the coal dealer as below, dried at 212° F.

Fixed carbon	63.02
Volatile matter	32.08
Ash	3.55
Moisture	1.35
	——100.00

The coal is given a heat value of 15,120 B. T. U. per pound combustible, and the wood a value equal to half its weight in coal.

The fuel was weighed at start, and what was left unconsumed on grate and in ash pan was weighed and taken from original amount.

The heat necessary to raise 375 pounds of water (boiler capacity) from 40 pounds steam pressure to $152\frac{1}{2}$ pounds average boiler pressure has been allowed in favor of the boiler efficiency. At no time was there any appreciable loss of steam by leaks.

The condensed steam was measured in buckets from start to finish, indicator cards were taken every 5 minutes for first half of trip and every 10 minutes thereafter on each cylinder.

The full boiler pressure never reached the high-pressure piston; a fact quite obvious on the cards and due to wire drawing through purposely cramped throttle.

Effort was rather successfully made to maintain uniform normal conditions throughout test.

Average steam pressure on boiler	$152\frac{1}{2}$ lbs.
Average revolutions	307 per min.
Average piston speed	409 ft. per min.
Average vacuum	20.65 in.
Average temperature of feed water	$94\frac{1}{4}$° F.
Temperature of circulating water	42° F.
Temperature of atmosphere	65° F.
Mean pressure in high-pressure cylinder	55 lbs.
Mean pressure in low-pressure cylinder	7.47 lbs.
Mean effective pressure in high-pressure cylinder	47.53 lbs.
Mean effective pressure in low-pressure cylinder	2.80 lbs.

Average indicated horse power of high-pressure cylinder . .	14.05
Average indicated horse power of low-pressure cylinder . .	3.00
	——17.05
Total average indicated horse power	17.05

Total pounds of water evaporated from $94\frac{1}{4}°$ F. feed water and at $152\frac{1}{2}$ lbs. steam pressure 2,475
Total pounds of coal consumed 281.5

Making allowance for the heat units necessary to raise steam at 40 pounds to steam at $152\frac{1}{2}$ pounds, and with feed water at an average temperature of $94\frac{1}{4}°$ F., the efficiency of boiler was $82\frac{1}{2}$ per cent.

Pounds of water evaporated per pound of coal, 8.8.

Pounds of coal burned per square foot of grate per hour, 12.1.

Pounds of water evaporated per hour per square foot of heating surface, 0.395.

Total steam consumed by engine, 71 per cent.

Total steam consumed by pumps, 29 per cent.

Thermal efficiency of engine, based on 2545 B. T. U. per horse power hour, 4.54 per cent. This low efficiency is partly due to the fact that there was no other duty on engine than propelling its own hull, also to a slightly undersized propeller and to a too great cut-off in high-pressure cylinder, necessitating a cramped throttle.

It is also important to note that, although the engine cylinders were covered with asbestos, the steam pipe from boiler to engine was exposed to a cold, stiff breeze and all pipes were uncovered; also that the engine was developing less than half its maximum horse power.

Total pounds of coal used per indicated horse power hour, 6.32.

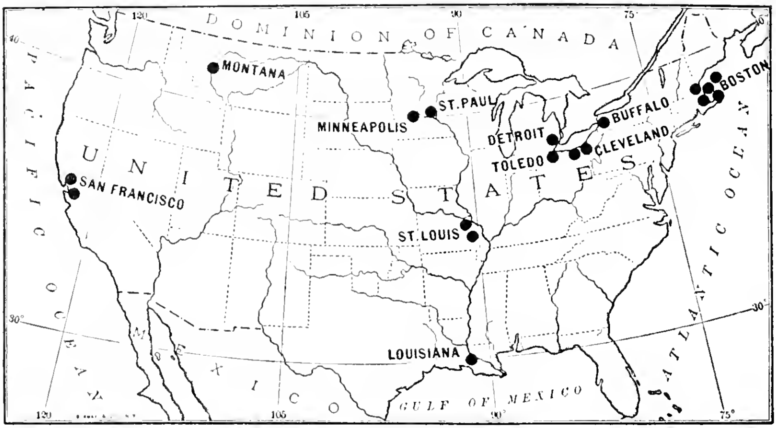
Total pounds of coal used for steam, through engine only, per indicated horse power hour, 4.50.

The total length of run was 22.8 miles or 19.8 knots in 2 hours and 36 minutes, a speed of 8.77 miles or 7.62 knots per hour.

The pitch travel of propeller was 12.2 miles per hour, a slip of 28.3 per cent.

We find that 4.46 indicated horse power was necessary per 100 square feet of wetted surface for a speed of 8.77 miles per hour, and, according to displacement, 0.714 horse power per hour was required for every 1000 pounds displacement. Although the hull has not fine lines, these values are fair.

On a previous trial, where speed was the object, $11\frac{1}{3}$ miles per hour was maintained without trouble.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

VOL. XXXIII. AUGUST, 1904. No. 2.

ORE-HANDLING PLANT AT THE CLAIRTON WORKS OF THE CRUCIBLE STEEL COMPANY.

BY CHAS. H. WRIGHT, MEMBER CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read before the Civil Engineers' Club of Cleveland, January 12, 1904.*]

ALL I shall attempt to-night will be to briefly describe how ore, limestone and coke are conveyed from the railroad cars to the furnace.

There are about 330 blast furnaces in the United States. To feed these furnaces there are taken, from the Lake Superior region alone, approximately 20,000,000 tons of ore per year. Since the mines were first opened over 200,000,000 tons have been taken from this region. To handle one year's output would take a train of cars reaching from New York to Salt Lake City; and still the output is constantly increasing and new furnaces are going up on all sides. Whether some of them will not be a poor investment in a few years remains to be seen.

One of the largest of the plants recently built is that of the Crucible Steel Company, at Clairton, just above McKeesport, on the Monongahela River. The plant at present consists of twelve 50-ton open-hearth furnaces, but is laid out with a view to a doubling of this capacity in the future should the demand warrant it. There was also organized the St. Clair Furnace Company, operating three 450-ton blast furnaces. This plant also is laid out with a view to future enlargements. The new works are located on 170 acres of bottom land at Clairton. The question of size was very carefully considered, with a result that 450 tons per furnace was decided upon, in preference to stacks of larger capacity. The

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* Manuscript received July 19, 1904.—Secretary, Ass'n of Eng. Socs.

mines, in which the company is interested, insure a supply of Mesaba ore, together with hard ores, for many years.

The blast-furnace plant at present consists of 3 stacks, 21 feet in diameter at the base by 85 feet in height, each stack being equipped with inclined skip hoists with electric hoisting engines. The stove equipment for each furnace consists of four 3-pass Massick and Crook's stoves, 21 feet in diameter by 95 feet in height. Blast is supplied to the furnaces by 7 cross-compound, condensing, steeple-type blowing engines, installed by the Southwark Foundry and Machine Company, of Philadelphia. Exhaust steam from the blowing engines is condensed by a 15,000 horse-power Weiss counter-current condenser. This condenser also handles the exhaust steam from all the auxiliary machinery, the pumping station and the electric power plant. Steam is supplied to the entire furnace plant by a battery of twelve 1000-horse-power Babcock and Wilcox boilers, the fuel being waste gas from the blast furnaces. The boilers also supply steam to the electric generating plant and to the pumping station.

Although the furnaces were designed for a capacity of 450 tons per day, they have actually produced more than this. One furnace, I believe, produced considerably more than 600 tons in 24 hours. This speaks well not only for the management, but also for the engineers who designed the furnaces. These men, by the way, were Cleveland men. One of them unfortunately did not live to see the successful completion of the plant. The machinery of the furnace hoist was built by the Otis Elevator Company, and the furnace top is of the double-bell type, as used by Julian Kennedy. There are at present 2 prominent types of furnace tops, one of them the 2-bell arrangement, and the other the rotating distributor type, as built by the Brown Hoisting Machinery Company. In the 2-bell arrangement there is a large lower bell and a smaller upper bell. As each skip-load of material is taken up to the furnace top it is dumped on the smaller or upper bell, which is then lowered, dropping the material on the large bell. After 4 or 5 skip-loads have been placed on the large bell in this manner it is lowered, and the material is dumped into the furnace. During the lowering of the large bell the small bell is closed, to prevent the escape of gas. In the rotating distributor system the large bell is used in practically the same manner as in the first arrangement, but, in place of the small upper bell, a rotating hopper and spout are used. This hopper is connected, by means of gears and shafting, with the large sheave around which the skip rope passes; and, every time the skip returns from the top of the furnace, it rotates this mechanism and turns the dis-

tributor through a portion of a circle. A ratchet arrangement, connected with this mechanism, is so arranged that, when the skip is going up to the top of the furnace, the ratchet simply slips by and the mechanism does not revolve, so that the hopper is rotated only by the return of the skip from the top; the weight of the skip car being more than sufficient to provide all the power necessary to rotate the hopper.

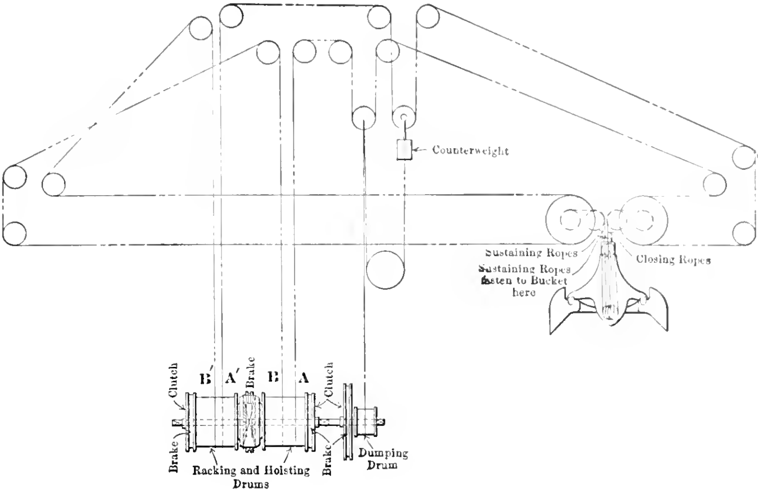
The angle through which the distributor moves at each trip depends upon the number of skip-loads which are used to make a load for the large bell. This is usually 4, and the distributor would turn through an angle of about 90°, a little more or a little less, so that no 2 successive revolutions would deposit the loads at the same points on the bell. The angle of rotation can be adjusted, and the material can be dumped at any desired point on the bell, and consequently placed at any desired point in the furnace. By this means a perfect distribution of the material can be obtained, not alone in theory, but also in practice. In the first tops which were built the distributor rested on 4 or 8 rollers, but this device was later replaced by a complete ring of balls about 3½ inches in diameter, resting in V-shaped grooves. Attached to the movable part of the hopper was a vertical lip which extended down into a trough attached to the fixed portion of the hopper. This trough was filled with sand, and, as the distributor rotated, this lip traveled around in the sand, the intention being to form a gas seal. It was found, however, that when the pressure reached a certain point or when there was a slight explosion, the sand would all be blown out and the seal ruined. This device, as well as the ball-bearing, is now replaced by a plain flat surface, on which the distributor rests. This surface is kept lubricated with powdered graphite and sometimes heavy oil, and is giving most excellent results, a perfect gas seal being formed and a simple means of rotation for the hopper provided. Attached to the hopper is a door, which is automatically closed whenever the bell is lowered, thus preventing the escape of gas. When the lower bell is closed the distributor door is always open, preventing the accumulation of gas in the upper part of the furnace top. Many furnace managers were rather skeptical when this top was introduced, as they claimed that a furnace top was the last place in the world where much mechanism should be placed, and that the extreme heat would soon warp and distort it, rendering it useless. Mr. Brown has demonstrated that, with proper care in design and protection for the mechanism, there need be no trouble from this cause; and it has run and will run for years, remaining in good condition.

The plant recently designed and constructed by the Brown Hoisting Machinery Company for the handling of material, ore, limestone and coke, at Clairton, consists briefly of the following items:

First. There is an electrically operated car dumper, which handles about thirty 60-ton cars per hour. The moving load, including the car itself, is 160,000 pounds. The material is dumped into a bin of 150 tons capacity, at the side of the tipple, from which bin it is drawn by means of spouts and gates, operated by a small motor, into bucket cars. The tipple is operated by two 130-horse-power motors, and is of the regular Brown type.

Second. The second item is a system of 6 electrically operated transfer cars and a suitable equipment of self-dumping tubs of $7\frac{1}{2}$ tons capacity. The transfer cars are arranged to run in pairs, each car being supplied with 35-horse-power motors, one car having a small cab, in which are placed the controller and mechanism for operating the cars. Each car carries 2 buckets. Current is supplied to the motors operating these cars by conductors of two $1\frac{1}{2}$-inch square wrought-iron bars. The current is taken from these conductors by means of sliding shoes at the end of an ordinary trolley arrangement. These transfer cars take the material from the bins at the tipple and transfer it to any convenient point along the front of the yard, from which the buckets are picked up by the bridge, and the material is dumped either on the stock pile or into the storage bins.

Third. There are two of the Brown patent traveling electric bridge tramways, having a span of 300 feet, a cantilever extension of 46 feet over the bins and a short extension at the pier, the extreme length of the bridge being 369 feet. Two 130-horse-power motors are provided for each bridge, and 1 operator controls all the movements of the buckets and the trolley, and the travel of the bridge itself along the yard. The moving load on the bridge is 24,500 pounds, and the engines are designed to move this load along the bridge at a rate of 1000 feet per minute and to hoist the bucket at 350 feet per minute. The travel of the crane itself along the tracks is about 75 feet per minute. The bridges are designed to handle $7\frac{1}{2}$-ton stocking tubs, or to take material from the stock pile and deposit it in the storage bins by means of $7\frac{1}{2}$-ton shovel buckets or 5-ton 2-rope grab buckets. The bridge operates on what is known as the rope system; that is, the movements of the buckets and of the trolley are controlled by ropes running from the trolley across the bridge and down the pier to the drums in the engine house. During the last year or two there has been a tendency to replace this rope


Counterweight
Sustaining Ropes
Closing Ropes
Sustaining Ropes fasten to Bucket here
Clutch
B′
A′
Brake
B
A
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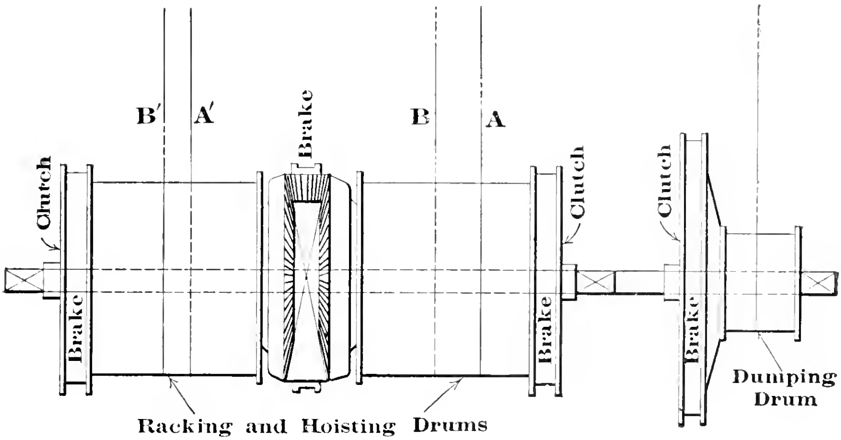
Racking and Hoisting Drums
Brake
Dumping Drum


B′
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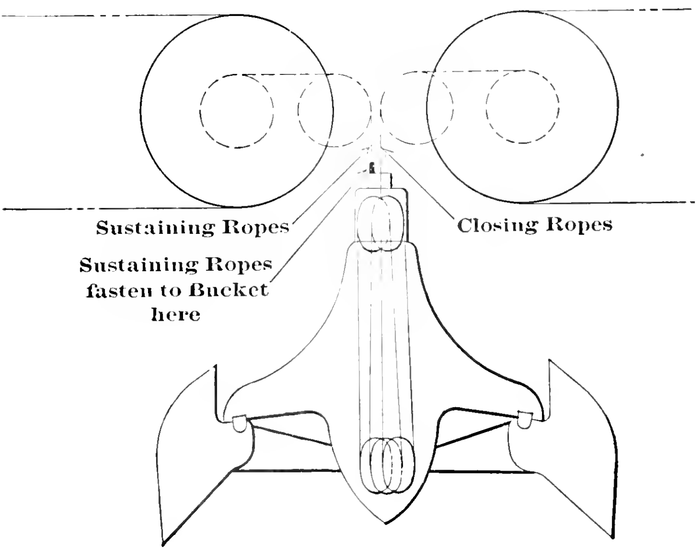
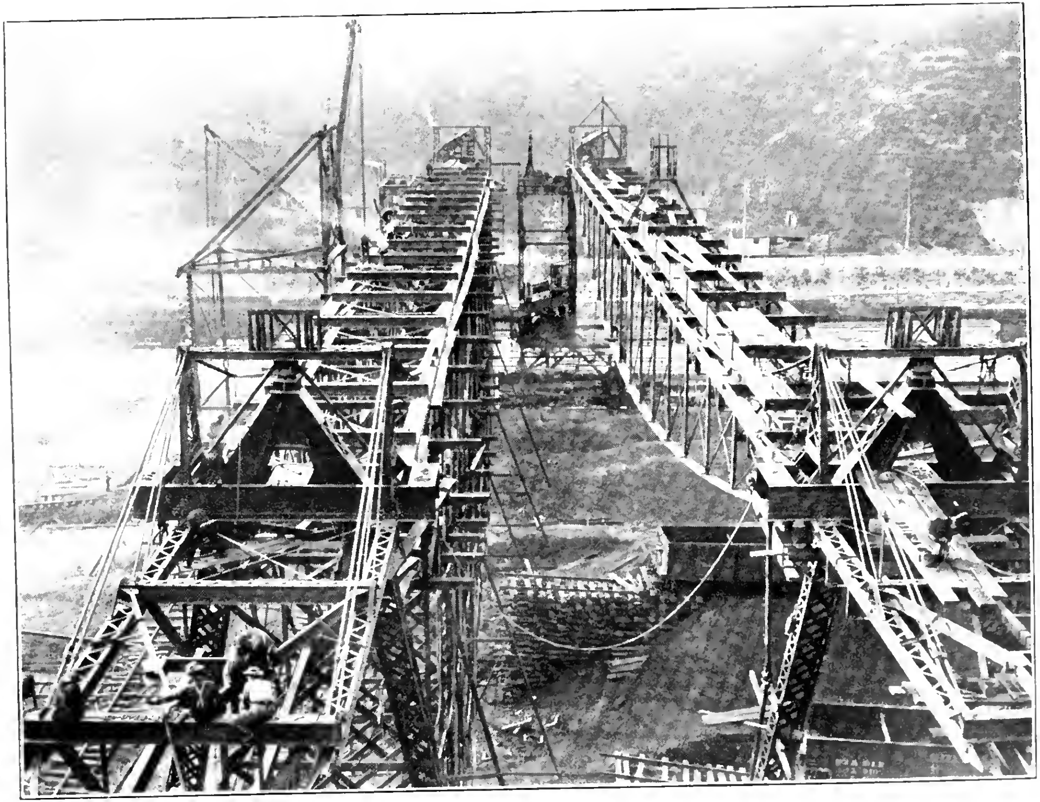
Racking and Hoisting Drums
Dumping Drum


Sustaining Ropes
Closing Ropes
Sustaining Ropes fasten to Bucket here

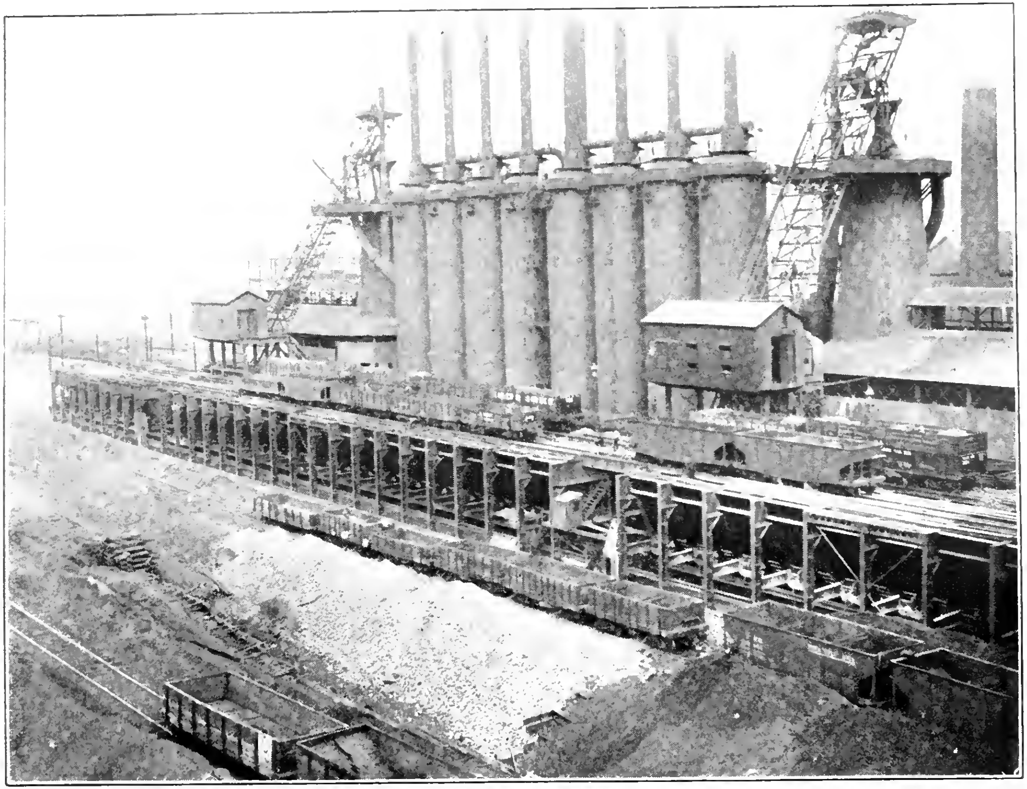
system by what is known as the man trolley arrangement. With the man trolley plan the operator rides on the trolley, and all the mechanism for operating the buckets and the trolley is also placed on the trolley. The first advantage of this plan is that the operator is always at the point where he is working, and can see exactly what is being done. The second advantage is that a large percentage of the ropes and expensive sheaves, bearings and supports are dispensed with. On the bridges at Clairton there are approximately $2\frac{1}{2}$ miles of rope on each machine. These ropes and their supports are, of course, an expensive item to install and keep in repair. An objection to the man trolley system is the fact that the moving loads of the structure are increased from 2 to $2\frac{1}{2}$ times over those where the rope system is used, and a very much heavier structure is necessary. There are many points which could be mentioned in favor of both systems. The Brown Hoisting Machinery Company has a large number of both types in operation.

During the last two or three years many have been working to design a grab bucket which would successfully handle ore. A bucket may handle coal very successfully, and yet a bucket built on the same lines may be a perfect failure when it is attempted to use it in ore. Some of the first buckets designed to handle ore were arranged to work on the same principle as the orange peel bucket used in dredging. This was not a success, and later buckets have been designed to act first as a scraper, scraping together a load of ore and then picking it up. There are several buckets now on the market doing successful work. The Brown Hoisting Machinery Company has just completed a bucket which bids fair to prove very satisfactory. The Hulett people have a good bucket, and the Mason & Hoover Company has a bucket which does most astonishing things. The first time I saw the bucket in operation I could explain how the operator was able to do what he did with it only on the ground that it was a practical application of the principles of Christian science. The bucket hung from the trolley by 3 or 4 ropes, and it seemed as though about all the operator could do was to open and close the bucket. I actually saw him make the bucket walk along a pile, stand up on one corner, pull a load of ore out of the side of a pile and turn over on its side; swing around under the hatches of a boat and scrape out a full bucket of ore. I should say this bucket would take 95 per cent. of the ore out of an ordinary boat.

There are two types of grab buckets, known as the 2-rope and single-rope types. In the 2-rope system there is a set of lines attached to the shell of the bucket, and the second set is attached to



Ore-Handling Bridges in Process of Erection, Showing Erecting Traveler and Construction Work in Detail.

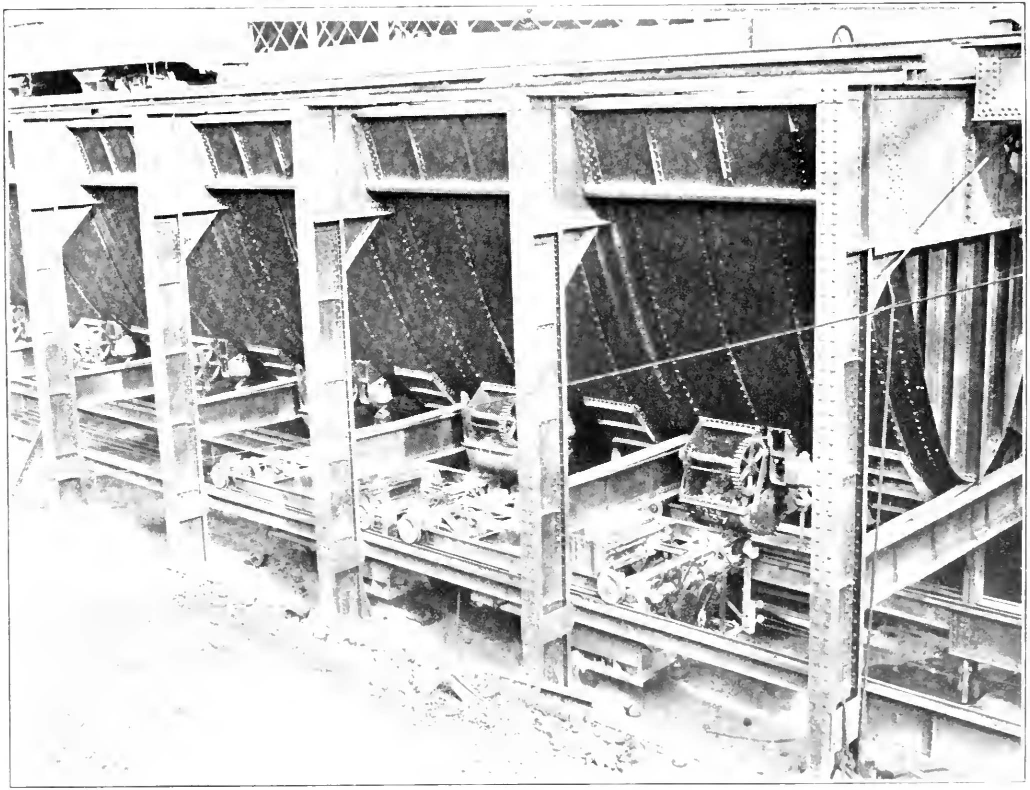


General View of Bins and Furnaces at Clairton.

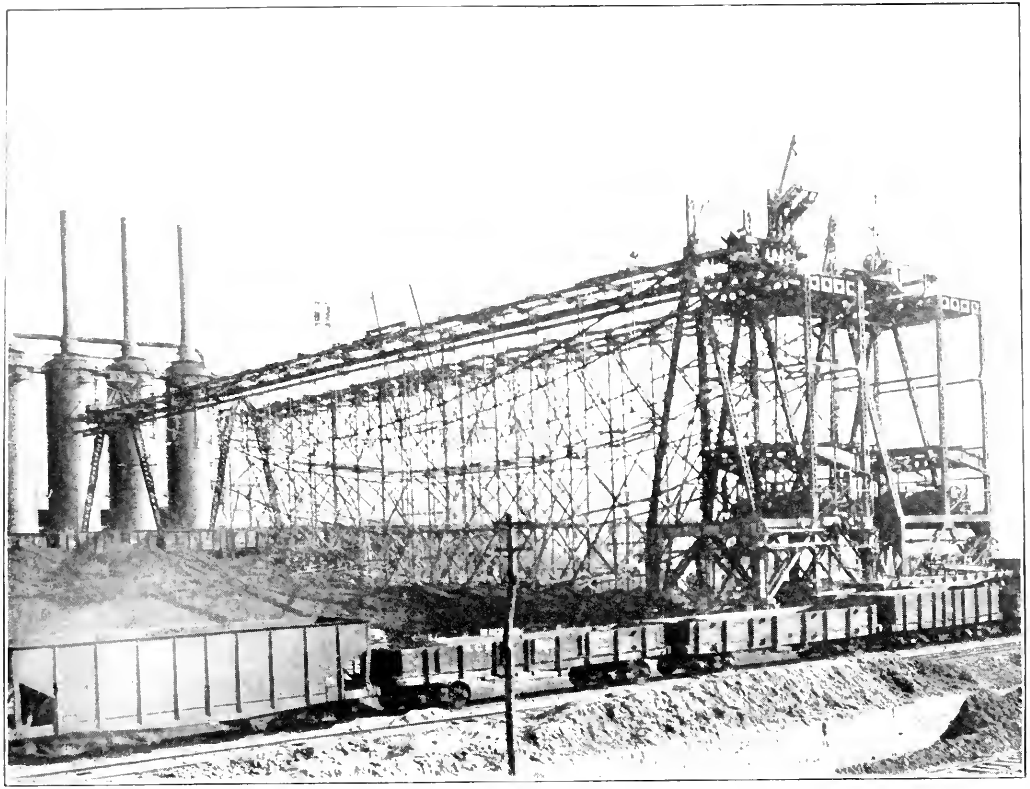
the blades by means of sheaves and suitable mechanism. By pulling up on the lines which are attached to the blades a load of ore is taken up, and the bucket is carried on these lines to the point where it is to be dumped; the load is then thrown over on the lines which are attached to the shell, and, by releasing the closing lines, the bucket is opened and the load is dumped. In the single-rope system there is no line attached directly to the shell, and, for most of these buckets, a second man is required to release the blades when the bucket has been opened or to adjust the mechanism for closing the bucket again. Mr. Brown has recently perfected and put on the market a single-rope bucket which does away with this extra man. With this bucket he is able to perform everything that can be done with a 2-rope bucket and only 1 man is required to operate it. When the bucket is to be dumped it is raised to the trolley, and the trolley is moved to the point where the bucket is to be dumped. The bucket then strikes a trapeze, which releases the mechanism attached to the blades, and the bucket opens. As the bucket is lowered on the ore again, this mechanism is automatically attached to the blades and the bucket is ready to close and to go through the operation a second time. A great advantage of this bucket is that, with very little change, it can be attached to the machines now in use, and will make these old rigs practically as valuable as the 2-rope machines. There is a large demand for these buckets, and the number which will be sold seems to depend largely upon the ability of the shop to turn them out. One of the most serious difficulties with which the makers of ore-handling machinery have to contend is the difficulty of reaching the ore between the hatches of a boat. It has been necessary to keep a gang of shovelers moving this material out under the hatches where the buckets can reach it. This difficulty has been overcome by the great Hulett machines, working at Conneaut, Buffalo and other places, by attaching the bucket to a vertical arm which rotates and also has a side motion, allowing it to carry the bucket underneath the framing between the hatches. This plan has been very successful in its work, and has made its designer justly famous. In some machinery which Mr. Brown is now building for Conneaut Harbor, he proposes to reach the material between the hatches by having the trolley suspended from a turntable. By rotating the turntable the bucket can be swung around after it has gone through the hatch, so that it can reach the material between the hatches. The spread of the bucket is made sufficient to reach from one hatch halfway to the next, so that practically all the material in the boat can be reached by this mechanism without scraping to the hatches. If the machine is as

successful as it seems likely to be, it will furnish a comparatively cheap machine, which will remove practically all the ore from a boat without the aid of hand-shovelers.

Fourth. There is a system of storage bins about 710 feet in length. These bins are arranged in a double line, one line being used for the storage of ore and limestone, and the second line for the storage of coke. The ore bins are of the parabolic suspension type, and have a capacity of 13½ tons of ore per lineal foot. The coke bins are in the form of a half parabola, one side of the ore bin also forming one side of the coke bin, effecting a considerable saving in material. The bins are divided into pockets of about 14 feet each. Of the pockets nearest the furnace, as many as necessary are reserved for the storage of limestone. There are 2 lines of railroad tracks on top of the bins, and all the coke is brought up on top of the bins and dumped directly from the cars into the pockets. The ore and limestone can also be dumped directly from the cars if this is desired. The sides of the bins are usually protected by either wooden or brick walls, to prevent the ore from freezing in the winter. In some bins now being built at Buffalo, the shell of the ore bin is made double, with an air space, and it is the intention to pump hot air into this space, and in this manner prevent the ore from freezing. The ore is drawn from the bottom of the bins into the larry. Underneath the bins are 2 tracks on which these larries run. The spouts under the bins are arranged alternately, so that the ore can be drawn off into the larries on either track as desired. These spouts are usually operated by electric power. In the first bins built of these types hand power was used. This proved not to be very satisfactory, and at Rankin a steam cylinder about 8 x 10 inches was attached to each gate. This cylinder, I understand, has worked very satisfactorily. Considerable care is, of course, necessary to prevent the freezing of pipes in cold weather. In other bins a longitudinal shaft has been used, running the full length of the bins and operated by motors, the mechanism at each gate being connected to the shaft by means of a jaw coupling. The controlling mechanism is also so arranged that the operator, at any gate, can start and stop the motor, so that the motor runs only while the gate is being used. In some of the later bins, the motor for operating the gates and most of the mechanism has been placed on the larry, this mechanism being connected to the portion which is fixed to the gate by means of a male and female coupling, which is thrown into mesh by means of a foot lever. This is the most satisfactory arrangement which has yet been installed for operating the gates. The gates of the coke bin are operated like those on the ore bins,



ORE BINS AND LARRIES AT CLAIRTON STEEL CO.'S PLANT



ORE-HANDLING BRIDGES AT CLAIRTON IN PROCESS OF ERECTION.

except that hand power is used, as these gates work much easier than those on the ore and limestone bins.

Fifth. The fifth item is the larry equipment for transferring the material from the storage bins to the skip-car, by means of which it is taken to the top of the furnace. The tracks on which these larries run are sometimes suspended from the bins, an I-beam being used for the tracks and the wheels of the larry running on the flanges. In other cases, I-beams or girders, with a railroad rail on top, are used, and in this case the track is placed 4 feet above the ground. In some cases the suspended track is preferable, and in some cases the regular rail construction is better.

There are 6 ore larries and 3 coke larries at Clairton. The coke larries are coupled to 3 of the ore larries, running on the same track, 1 operator handling both the ore and coke larries. The ore larries have a capacity of 75 cubic feet and the coke larries a capacity of 120 cubic feet. On the ore larries there are scales for weighing the ore and limestone. The larries will run the full length of the bins, and can take material from any bin and load it into the skip at any furnace. Ordinarily there would be 2 ore larries and 1 coke larry at each furnace. Only 1 operator is required to draw the material from the bins into the larries. There are 2 small motors on each of the ore larries, one for operating the bin-gate mechanism and the other for moving the larry. Different types of these larries are in successful operation. At Rankin the locomotive was made independent of the larry, 1 locomotive hauling 3 or 4 larries if desired. At the Cleveland furnace the larry is made double, 1 frame containing 2 larry buckets and all the mechanism for traveling the larry. For a furnace in Alabama some larries were recently built in which hand power was used for moving the larries along the track, as it was only a short distance from the farthest bin to the furnace. These larries have been able to easily keep the furnace supplied with ore and limestone. At most furnaces the coke bins are so arranged that the material is drawn directly from the bins into the skip, by which it is taken to the top of the furnace, no larry being required for handling this material.

The weight of the car dumper at Clairton is about 650,000 pounds; the weight of each of the bridges is approximately 700,000 pounds. Each pair of transfer cars weighs approximately 30,000 pounds. The weight of the bins, complete, is in the neighborhood of 3,300,000 pounds, the weight of the larries about 16,000 pounds.

The general arrangement of the yard is as follows:

Next to the railroad tracks, which are on the side of the yard farthest from the line of furnaces, there is a storage yard of large

capacity for storing loaded cars, and also for the storage of the empty cars after they have left the car dumper. At the side of this storage yard next to the furnaces is a track on which the car dumper is placed. A system of switches enables the cars to be run in from any storage track onto the track leading to the tipple. The loaded cars, after they have been pushed down, either by locomotive or by gravity, to a point near the tipple, are pushed up an incline into the tipple by means of a "ground hog" or disappearing car, which runs into a pit below the track, enabling it to get out of the way of the loaded cars. After a car has been run into the tipple and dumped, the "ground hog" pulls another car up onto the incline and into the tipple, pushing the car just dumped out of the way, down an incline from the tipple, from which the car is automatically switched back into the storage yard for empty cars. Only 1 operator in the tipple is required to unload the cars and switch them back into the storage yard after they have once been run down to the point where they can be reached by the "ground hog."

The tracks for the transfer cars run along the yard parallel to the storage track, and are so arranged that the loaded cars, after leaving the storage bin at the tipple, are automatically switched back on the track underneath the pier of the bridge, and, when the buckets have been emptied by the bridge, the train of empty cars continues on down the track to the end of the storage space, and is then switched back onto the track which takes them underneath the bin again, the switches being so arranged that they are thrown automatically, no switchmen being required.

Between these transfer tracks and the storage bin at the furnaces is a space about 300 feet in width and 1000 feet in length, which is used for the storage of the various kinds of ore and limestone. This entire space can be covered by either bridge, so that if desired both bridges can be working upon the same kind of ore at the same time, or one bridge can be unloading ore onto the stock pile, while the second bridge is either loading ore from the transfer system into the bins direct or is taking ore from the stock pile and supplying the bins.

The runway tracks for the bridge tramways are arranged to straddle the bucket car tracks, the tipple being placed at one end of the yard, so that no crossings are required for the bucket car tracks over the crane tracks. In other words, the transfer cars never have to cross the tracks which carry the bridge tramways.

Only one operator in the house on each bridge tramway is required for the handling of either the dumping tubs, shovel bucket or grab bucket, and, when the bridges are using either the shovel

bucket or the grab bucket, only 1 man is required for the handling of the ore from the stock pile into the bins. When the transfer cars are being used, 2 men are required on each train of cars, to hook on and unhook the tubs, and a third man is usually employed to move and control the train of cars.

Allowed Stresses.	Medium Steel.	Soft Steel.	Iron.
Tension—			
Live loads. Counters and similar members..	....	8,500	7,500
Live loads. Chords, girders and similar members	13,000	11,500	10,000
Live loads. Stringers and similar members..	13,000	11,500	10,000
[Subject to shock]	9,500	8,500	7,500
Dead and wind load........	16,500	14,500	12,500
Do not use stringers with thin web [provide ample stiffness.]			
Compression—			
Live load. Members subject to shock......	11,000	9,000	7,500
Live load. Members not subject to shock..	13,000	11,500	10,000
Dead and wind load........	16,500	14,500	12,500
Reduce by column formula when $\frac{\text{l in feet}}{\text{r in inches}}$ = more than 4.			
Shearing—			
Girder webs	9,000	7,500	6,000
Rivets, bolts and pins. [General]........	....	9,000	7,500
Rivets, bolts and pins. [In sheave supports].	....	8,000	6,000
Bearing—			
Rivets, bolts and pins. [General]........	....	18,000	15,000
Rivets, bolts and pins. [In sheave supports].	....	15,000	12,000
Bending—			
Rivets, bolts, pins and post ends. See sheet No. 25,580	....	18,000	15,000
Gas-pipe posts. See sheet No. 25,580.......	....	7,500	7,500
Axles of sheaves, hoist blocks, trolleys, etc..	....	15,000	12,000
Axles of truck wheels	....	15,000	12,000
Shafting—			
Bending. (Solid shaft)	15,000	12,000	10,000
Bending. (Pipe shaft)	....	7,500	7,500
Torsion. (Solid shaft)	12,000	10,000	8,000
Torsion. (Pipe shaft)	....	6,000	6,000
Shafts and axles over 5½ inches diameter to be of hammered steel.			

Journal Pressures—

For slow-running well-oiled bearing allow 1000 to 1200 pounds per square inch; for heavy loads or high speeds allow 400 to 800 pounds per square inch.

Gear Teeth—

Strain per square inch, cast iron or bronze, 3000 to 6500 pounds.

Strain per square inch, cast steel, 8,000 to 18,000 pounds, depending on service.

For spurs, add 4 per cent. for friction.

For bevels, add 8 per cent. for friction.

For worms, take efficiency at 40 per cent.

Note.—Do not use a steel worm with a steel worm wheel.

Wherever possible have sliding surfaces in contact of different material.

Figure no structure for a smaller moving load than 7000 pounds.

Where bent welded loops are used unit stress should not exceed 6000 to 7000 pounds.

Avoid eccentric stresses; make all, even unimportant, members meet at intersection of center lines.

Ultimate—

50,000, 58,000 and 66,000.

COMPARATIVE TABLE OF DIMENSIONS OF AMERICAN AND BRITISH BLAST FURNACES.

			American.	British.
Height, feet			75	60
			80	65
			106	85
Hearth diameter, feet			11	10
			11	10.5
			15	11
Bosh diameter, feet			20	18.5
			22	19
			23	20
Internal capacity	cubic feet		14,600	10,012
			19,800	12,610
			26,500	18,495
	cubic feet per ton per diem		73	105
			60	87
			46	89
Output, tons per diem			200	95
			330	145
			570	206
Coke consumed, pounds per ton of iron			1,912	2,352
			1,884	2,268
			1,780	2,206
Blast	temperature, Fahrenheit		1,100	1,100
			1,100	1,100
			1,100	1,100
	pressure, pounds per square inch		5	5
			10	6
			15	7
	consumption	cubic feet per minute	16,000	9,540
			25,000	13,500
			50,000	17,263
		cubic feet per ton of iron	115,200	144,606
			109,090	134,068
			126,315	120,673

SPECIFICATIONS.

Specifications for one ore-handling plant, referred to in letter to the Crucible Steel Company of America, dated February 15, 1902, and consisting of car tipple, transfer cars, automatic self-dumping buckets, bridge tramways, shovel buckets, grab buckets; ore, limestone and coke bins; suspending trolley tracks, overhead railroad tracks connecting bins; ore and coke-bin chutes and gates; electric charging larries, and chutes for conducting material into skip-cars.

MATERIAL.

The various parts of the plant are to be built entirely of iron and steel, except the footways on top of the bridge tramways, doors, windows and floors of transfer cars, larries and operators' houses, which are to be of wood.

STRAINS.

All members of the said plant to be designed and constructed of ample strength for the loads to be carried.

The said plant to comprise:

CAR TIPPLE.

The car tipple is to be similar in construction and capacity to those furnished for the Carnegie Steel Company, at Rankin, Pa. It will be capable of handling open or gondola cars of the present standard dimensions up to 60 tons of maximum loads, including the weight of the car of 160,000 pounds; the contents of the car to be dumped into a bin having a capacity of about 100 tons.

From this bin the material is drawn off, by means of a special system of gates and mechanism, into buckets of 7½ tons capacity, resting on cars. When loaded, these buckets are conveyed, by means of these electrically driven cars carrying 2 buckets each, to such position as may be necessary for handling them by the bridge tramway.

STRUCTURE FRAME.

The structure consists in general of a rectangular frame, of such dimensions as to include the cradle and framework for holding and dumping the car. On top of the frame the engine house and operator's house are located, these houses being of sufficient size to give ample room for the machinery and for the operator to control the same. Framework is also provided for the support of the counterweight and its sheaves.

CRADLE.

The cradle consists of 2 U-shaped girders attached to the frame by the large pins around which they rotate. These girders are connected by longitudinal beams carrying the track and which form a system of bracing for the cradle. The cradle also forms a support for the various clamping devices. The motion of the cradle is controlled in part by the counterweight connected to it by a system of ropes and sheaves.

CLAMPING DEVICES.

The clamping device for holding the car will consist of 4 independent sets of clamps, which bear against the side and top of the cars. These clamps are so designed as to hold open cars of the present standard dimensions up to 60 tons capacity. The clamps are operated by a special hydraulic system of mechanism, pressure being obtained by a small independent motor.

COUNTERWEIGHT.

The counterweight, which partially controls the motion of the cradle, consists of a cylinder of sheet steel, and filled with ore or pig iron. The position of the counterweight is such that it is adjusted for the desired effect upon the cradle and its load.

DISAPPEARING CAR.

The "ground hog," which is used for hauling the loaded cars up the incline into the tipple, consists of a cylinder of sheet iron, filled with ore and resting on track wheels on rails between the standard gauge rails used by the cars. When not in use, the ground hog is lowered into the pit beneath the track, the motion being controlled by the operator in the tipple house.

ENGINE AND OPERATORS' HOUSES.

The engine and operators' houses to consist of a steel frame covered with corrugated iron sides and roof, provided with a sufficient number of windows to enable the operator to observe the entire operation of the plant, and will be provided with ladders and doors for entrance to same.

ENGINE.

(1) The engine to consist of sufficient drums and mechanism for hoisting and rotating the cradle.

(2) The drums, sheaves and mechanism for operating the disappearing car.

(3) The operating mechanism necessary for controlling the various functions of the machine.

ELECTRICAL EQUIPMENT.

Electrical equipment shall consist of two 130-horse-power Elwell Parker electric motors using 220 volts direct current; also such controllers, resistance boxes and wiring as may be necessary for operating and controlling the same.

HYDRAULIC EQUIPMENT.

Hydraulic equipment shall consist of 1 triplex pump, operated by an electric motor and provided with pressure regulating valve and the necessary tanks, accumulator, valves, piping and cylinders for operating the various clamps for holding the car while being dumped.

TUB TRANSFER CARS.

Six steel cars with oak platforms; 3 of the said cars to be equipped with motor, controller, resistance boxes, etc. Each of the steel cars to be large enough to carry 2 of the 7½-ton automatic dump buckets.

AUTOMATIC DUMP BUCKETS OR TUBS.

Fourteen of Brown's patent self-dumping ore tubs or buckets, of 7½ tons capacity each.

BRIDGE TRAMWAYS.

Two of Brown's patent trussed bridge tramways, each of 300 feet span, with cantilever at one end of 43 feet, and a tramway extension at the other end of 14 feet, making a total trolley travel of 341 feet, and a total length from end to end over all of 357 feet, and of the further general dimensions as indicated.

PIER.

Said bridge to be supported at one end of the span on 1 double-track pier and on the other end by a single-track pier and shear leg. The double-track pier is to be arranged to be mounted on parallel tracks, 28 feet center to center, and arranged to straddle 2 standard railroad tracks 12 feet center to center. The said single and double-track piers to be constructed entirely of iron and steel, mounted on chilled faced double-flanged track wheels, and provided with suitable and convenient moving gears to move them along the rails or tracks on which they are mounted.

MOVING GEAR.

The moving gear for each of the single and double-track piers to be arranged to be operated by power and controlled from the operator's house on the double-track pier.

AUTOMATIC SAFETY DOGS.

Each of the single piers is to be provided with a set of steel safety dogs, arranged to automatically drop onto the heads of the rails on which the pier is mounted when the bridge tramway is skewed in either direction from the center line to the allowable working limit.

PATENT SAFETY CLAMPS.

Each of the said piers is to be provided with a set of Brown's patent safety clamps, with safety jaws arranged so that they will always be under the head of the rail for securing the piers to the track when not being moved.

TROLLEY.

Each bridge to be supplied with 1 of Brown's patent hoisting and conveying machines, and all the necessary sheaves, pulleys and wire rope for the operation of either a shovel bucket or a 2-rope grab bucket.

CAPACITY.

Each of the said bridge tramways to be of sufficient capacity to handle 7½ gross tons of ore with either the automatic dumping buckets or shovel buckets, and 5 gross tons of ore with the grab bucket.

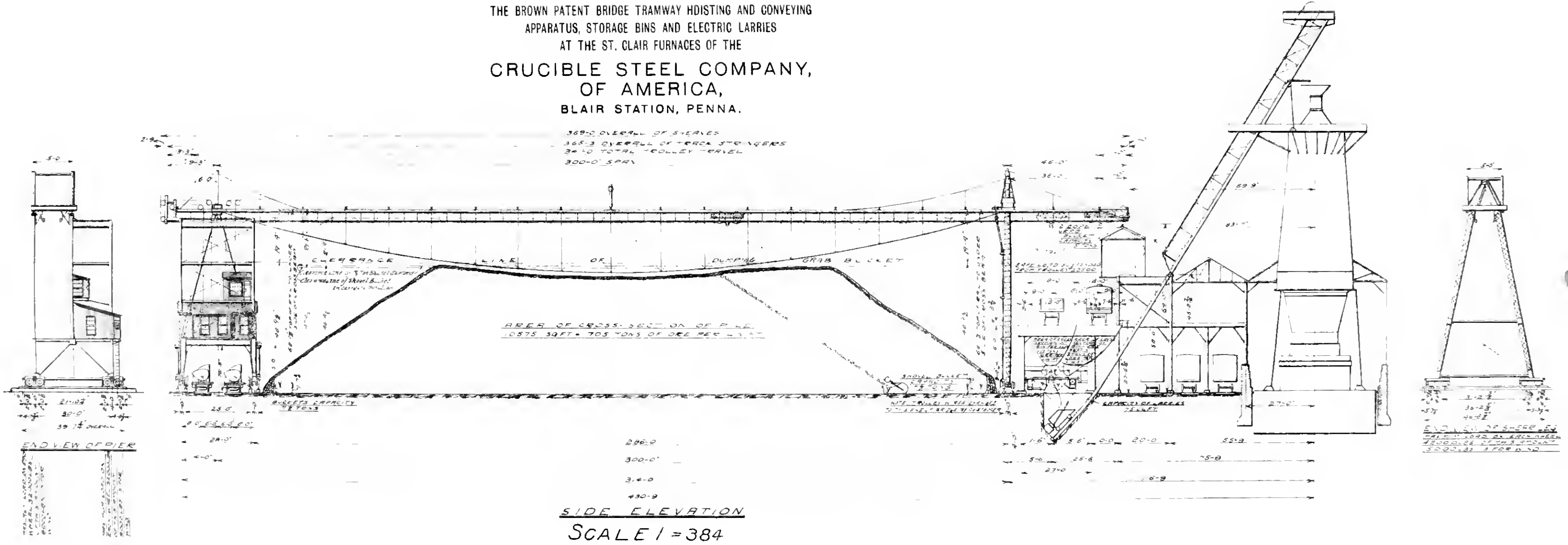
ENGINES.

Each of the said bridge tramways to be supplied with 2 special electric motors, together with hoisting and racking drums operated and controlled

THE BROWN PATENT BRIDGE TRAMWAY HOISTING AND CONVEYING APPARATUS, STORAGE BINS AND ELECTRIC LARRIES AT THE ST. CLAIR FURNACES OF THE

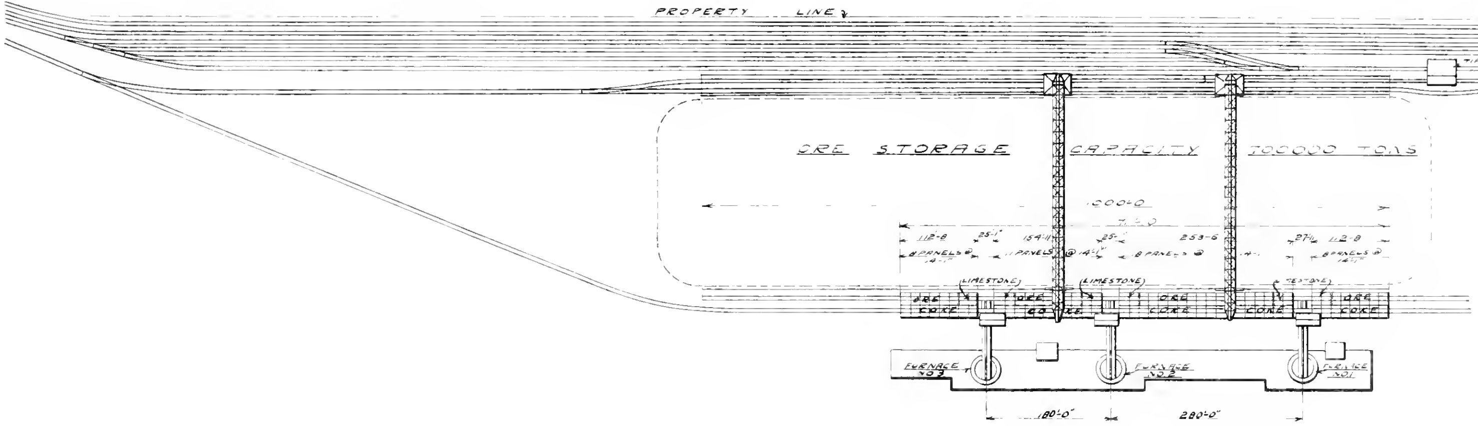
CRUCIBLE STEEL COMPANY, OF AMERICA,

BLAIR STATION, PENNA.



SIDE ELEVATION

SCALE 1 = 384



PLAN
SCALE 1" = 1200 FT.

by Brown's patent band friction clutches and brakes. Each of the said drums to be of sufficient face to hold the respective hoisting and pulling lines in the groves without overwinding; the engine to be furnished with suitable levers and foot brakes, whereby the operator can control the motions of hoisting, lowering, bridge travel and trolley travel.

SPEEDS.

The electric hoisting engines will be capable of hoisting the full load in either the automatic dump bucket, shovel bucket or grab bucket at the rate of 350 feet per minute; to travel the same along the bridge at the rate of 1000 feet per minute, and to travel the whole bridge with full load at the rate of 75 feet per minute.

SHOVEL BUCKETS.

Each bridge to be equipped with 1 of Brown's patent shovel buckets, of 7½ tons capacity each.

GRAB BUCKETS.

Each bridge to be equipped with 1 of Brown's patent 2-rope grab buckets, of 5 tons capacity each.

PARABOLIC BINS.

Six hundred and thirty-three feet nine inches of steel parabolic bins, supported on steel piers or columns, and of the same general design and dimensions as shown.

There will also be provided railroad tracks on top of the bins, 18 feet center to center, and suspended trolley tracks underneath the bins.

SUSPENDED TROLLEY TRACKS AND OVERHEAD RAILROAD TRACKS.

Seventy-eight feet one inch of suspended tracks and overhead railroad tracks connecting bins hereinbefore referred to, in front of each furnace, and spaced as shown.

ORE-BIN CHUTES AND GATES.

Ninety ore-bin chutes and gates attached to and made a part of the bins above referred to, to be operated by electricity, steam or air, as may be preferred and decided later on by the St. Clair Furnace Company.

In case electricity is used, there will be furnished the necessary motors, line shafting, etc., to operate the gates. If steam is used, each gate will be provided with its own cylinder levers, etc., necessary to operate the same, and likewise there will be provided piping immediately underneath the bins, but not extending beyond the line of the same. Also in this case the necessary steam power will not be provided. Should it be decided to use air, neither the air compressor, receiver nor piping beyond the line of bins will be furnished.

COKE-BIN CHUTES AND GATES.

Forty-five chutes and gates to be operated by hand and attached to the parobolic bin to be used for the coke supply.

4

ELECTRIC CHARGING LARRIES.

Six electrically operated steel charging larries, of Brown's special design, of 75 cubic feet capacity each, arranged to run on I-beam tracks, underneath the bins. Each larry to be equipped with one 4-lever scale of 10,000 pounds capacity each.

COKE LARRIES.

Three specially designed coke larries of 120 cubic feet capacity; each to be made so that it can be coupled up and used in connection with the ore-charging larry on the suspended track beneath the coke bin.

ORE AND COKE CHUTES.

Three chutes for conducting ore, coke and limestone from the charging larries into the skip-cars, to be made of steel.

PAINTING.

All structural work to be properly painted at the works with 1 coat of linseed oil, and, after erection, with another coat of linseed oil and iron-ore paint. All inaccessible parts to be painted with 2 coats of iron-ore paint before assembling. All bright parts of the mechanism to be properly slushed before leaving the works.

QUALITY.

The said plant to be in quality of material used, capacity to perform the work for which it is intended, workmanship and in all other respect equal to any of the like plants heretofore constructed and erected by the Brown Hoisting Machinery Company.

MECHANICAL FLIGHT.

By J. Emery Harriman, Jr., C. E.

[Read before the Boston Society of Civil Engineers, May 4, 1904.*]

I shall confine my address mostly to flying machines heavier than the air displaced by them, and shall have but little to say about propelled balloons, except at intervals showing some of the most noted experiments, as they are in an entirely different class.

I shall begin by reading a short description of flight written by J. Bell Pettigrew, published in book form in 1874. He writes:

"However paradoxical it may seem, a certain amount of weight is indispensable to flight. Power and weight may be said to reciprocate by blending their peculiar influence to produce this common result.

"In the aërial machine, as far as yet devised, there is no sympathy between the weight to be elevated and the lifting power, while in natural flight the wings and weight of the flying creature act in concert and reciprocate; the wings elevating the body the one instant, the body by its fall elevating the wings the next.

"Weight, assisted by the elastic ligaments or springs which recover all wings in flexion, is to be regarded as the mechanical expedient resorted to by nature in supplementing the efforts of all flying things.

"Without weight, flights would be of short duration, labored and uncertain, and the almost miraculous journeys at present performed by the denizens of the air, impossible.

"Flight may be divided into 2 principal varieties, which represent 2 great sects or schools.

"1st. The balloonist or those who advocate the employment of a machine specifically lighter than air.

"2d. Those who believe that weight is necessary to flight. The second school may be subdivided into—

"A. Those who advocate the employment of rigid inclined planes driven forward in a straight line by revolving planes (aërial screws); and

B. Such as trust for elevation to the vertical flapping of wings.

"To construct a wing which shall elude the air during the up stroke it is necessary to make it valvular, so arranged that the air, when the wing is made to vibrate, opens or separates the valves at

* Manuscript received July 18, 1904.—Secretary, Ass'n of Eng. Socs.

the beginning of the up stroke, and closes or brings them together at the beginning of the down stroke. Repeated experiment has convinced me that the artificial wing must be thoroughly under control both during the down and up strokes.

"The artificial wave wing can be driven at any speed. It alternately seizes and evades the air so as to extract the maximum of support with the minimum of slip and the minimum of force.

"It supplies a degree of buoying and propelling power which is truly remarkable. It can act upon still air, or it can create and utilize its own currents. The fact that the wing of the insect, bat or bird can be readily imitated and reproduced should inspire the pioneer in aërial navigation with confidence.

"In attempting to produce a flying machine it is not necessarily attempting an impossible thing. Of the many mechanical problems before the world at present, perhaps there is none greater than that of aërial navigation."

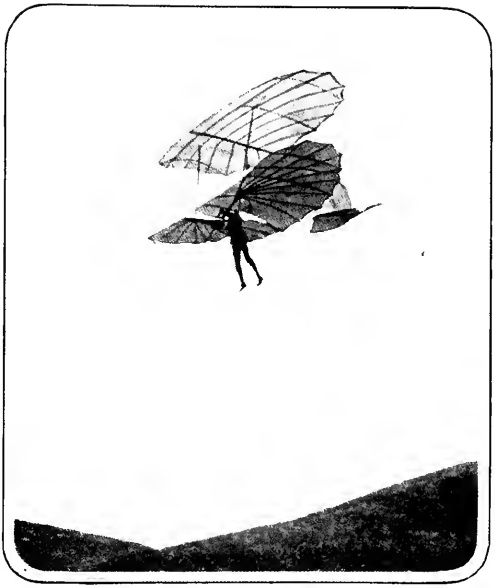
In 1889 Otto Lilienthal, a German engineer, mathematician, ingenious inventor and skillful experimenter, published a book on mechanical flight, and made hundreds of experiments with gliding machines of his own design and make.

He made a number of aëroplane machines, and used gravity for the motive power, starting from high hills and soaring to the plains below. He said that the construction of a flying machine for practical operation in nowise depends upon the discovery of light and powerful motors, as, with an ordinary wind, man's strength is sufficient to work efficiently an appropriate flying apparatus.

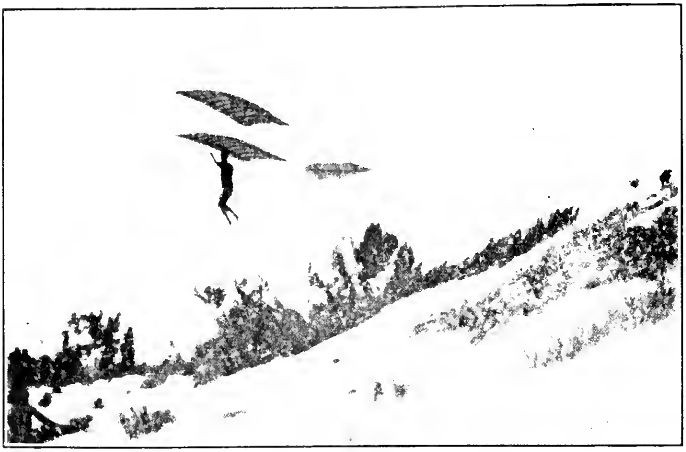
In order to operate such an apparatus with the greatest possible economy, it should be based, both in shape and in proportion, upon the wings of large high-flying birds. The framing and spars should be in the front edge of the wings, as far forward as possible, and the wing tips should encounter as little resistance as possible on the up stroke. No amount of motive power will avail unless the machine can rise, sail and come down again without danger of losing its equipoise.

Experiments should be carried on preferably with full-sized machines carrying a man, and arched wings should be used in preference to plane ones. Lilienthal "demonstrated the feasibility of actual practice in the air, without which success is impossible, and in so doing made the greatest contribution to the solution of the flying problem that had ever been made by any one man."

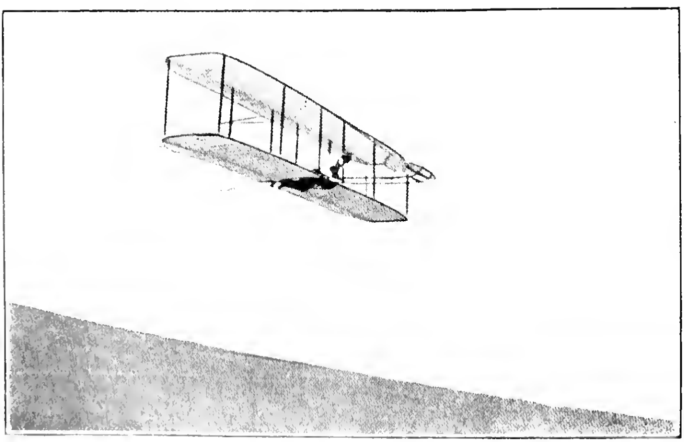
Following Lilienthal's experiments, Mr. Pilcher, an English



Herr Lilienthal's Flying Machine.



THE SOARING MACHINE OF OCTAVE CHANUTE.



THE WRIGHT BROTHERS' GLIDING MACHINE

engineer, slightly improved the apparatus and made many hundred glides.

Mr. Octave Chanute, of Chicago, past President of the American Society of Civil Engineers, has contributed greatly to the problem of mechanical flight, not only by encouraging writings and lectures, but by building gliding machines and making interesting experiments with the assistance of Mr. A. M. Herring, a civil and mechanical engineer. In his latest article on aërial navigation, published in the *Popular Science Monthly* of March, 1904, Mr. Chanute writes:

"After 4000 or 5000 years with a problem that has impassioned man, a successful flying machine seems to have been produced by the Messrs. Wright."

In 1897, in his address to the Western Society of Engineers, he said that, "As an engineer, approaching the end of his professional career, it seemed an opportune time to devote some of his leisure to the investigation of the laws which must be hereafter observed by other engineers in compassing the navigation of the air." He said he had hitherto abstained from addressing his fellow-engineers on the subject as some might deem it premature; but he had become convinced, not only by investigation, but through practical experiment, that it was not only possible but almost certain that man will eventually be enabled to make his way through and on the air by dynamic means.

Mr. Chanute took up—

1st. The supporting power and resistance of air.

This first problem is the foundation of the whole subject, and, singularly enough, it is only within the last 6 years that it has been settled beyond question what is the true measure of those properties of air when meeting a surface at an oblique angle of incidence.

2d. The motor: its character and its energy.

This second problem, now nearly solved, was, until 5 years ago, thought to be still more difficult than the obtaining of supporting power from the air. Great advances have been made with petroleum motors, which possess the great merit of dispensing with a boiler, so that, for the first time, the realization of a sufficiently light motor for a dynamic flying machine seems to be within sight.

3d. The instrument for obtaining propulsion.

Mr. Maxim and Professor Langley have made experiments to determine the best form, speed and pitch of the screw to obtain thrust from the air, and have materially improved that instrument which, to reason from analogy in land and water transportation,

seems likely to prove the best device; but both Mr. Hargrave and Mr. Lilienthal have obtained very favorable results with the flapping pinion, which requires no intervening machinery to change the reciprocating action of a piston into a rotary motion, and it seems perhaps possible that success in artificial flight may be obtained by either or both devices.

4th. The form and kind of the apparatus.

(1) Wings to sustain and propel. (2) Rotating screws to lift and propel. (3) Aëroplanes or aërocurves, to consist of fixed surfaces driven by some kind of propelling instrument.

5th. The extent of the sustaining surfaces.

The extent of the sustaining surfaces required to support the weight of a man has in the past caused active controversy and gathering of data. In point of fact, the amount required depends upon the speed of the creature's flight.

6th. The material and texture of the apparatus.

For a beginning, wood will do very well. It is a fact realized by few engineers that the best woods, so long as they remain undecayed, are actually stronger in proportion to their weight than the ordinary grades of steel. Wood is easily and cheaply procured and shaped, and whatever success has hitherto been had in gliding flight has been accomplished with wooden frames covered with textile fabrics.

7th. The maintenance of the equilibrium.

The first requisite for this is that the center of gravity shall constantly be in a vertical line with the center of pressure, and unfortunately the latter is almost constantly varying with the relative wind, with the speed and with the angle of incidence. Until automatic equilibrium is secured and safety is thereby insured under all circumstances, it will be exceedingly dangerous to apply a motor and a propeller.

8th. The guidance in any desired direction.

It has been generally supposed that this would be best effected by horizontal and vertical rudders, but the experiments of Lilienthal and others have shown that slight changes in the position of the center of gravity are more immediate and effective.

9th. Starting up under all conditions.

The solution of the question as to the best methods of starting away from the ground is likely to be one of the last to be practically worked out.

10th. Alighting safely anywhere.

This is the problem which always produces a smile upon its bare enunciation, probably in remembrance of that little experiment

of Darius Green. It may be said to be yet unsolved for the dynamic machine of the future, and yet both Lilienthal's experiments and others showed this problem to be very easy of solution with a gliding machine by simply making use of increased air resistance at greater angles of incidence to stop the headway before alighting on the ground.

Mr. Chanute has carefully prepared his reports of all experiments and illustrated them with more than 30 photographic half-tone pictures.

Mr. Hiram Maxim, the inventor of the Maxim gun, an American in England, Professor Langley of the Smithsonian Institution, Mr. Hargrave in New South Wales and Mr. Lilienthal in Germany in 1888, all at about the same time took up this study of mechanical flight.

Mr. Maxim experimented at a cost of more than $100,000, and constructed an enormous aëroplane weighing more than 8000 pounds with the men, water and fuel on board. It was driven ahead by 2 large screw propellers, 17 feet 10 inches in diameter and 5 feet wide at the tip of the blade. The whole machine rested on wheels on a track of 8-foot gauge, with an upper track to hold the machine down while making experiments under speed. The framework was of strong, thin steel tubes, stayed with steel wires, and the horizontal shape of the surface plane was almost an octagon, covered with varnished balloon material, with a smaller, narrow superposed plane. The angle of the aëroplane was 1 in 8, as Mr. Maxim wished to get as great a lifting power as possible on the comparatively short track with relatively low speed. When the steam pressure reached 363 pounds per square inch and the machine was driven forward, it rose from the lower track and passed upward to the guard track and even tore up about 100 feet of the guard rails before the machine was stopped. Mr. Maxim writes that when, on the first occasion, his aërial apparatus lifted itself clear of the tracks by the energy of its own engines, he felt that the ultimate success of the flying machine was assured.

Professor Langley was the first one to successfully demonstrate, on May 16, 1896, in actual flight, without an operator, a mechanical model flying machine. After years of careful study and experiment he has tabulated most important information that will be of value to all who follow in his line. He made the remarkable and, to the engineer, paradoxical statement that, in such aërial navigation as was there shown to be possible under certain definite conditions, the power required would in theory diminish indefinitely as the speed increased, and that it would actually diminish in prac-

tice up to a certain limit. His experiments have been made in such a thorough, scientific and theoretical way, with every minute detail worked out for every separate part, that it has cost a large sum of money for preparation before a full-sized machine was even constructed; but this expenditure by the Government should not be begrudged, for he has published and fully illustrated all his experiments, which are invaluable to those who will follow in his line.

Closely following Professor Langley's latest experiments, is the remarkably successful demonstration, by Messrs. Wilber and Orville Wright, engineers, of Dayton, Ohio, with their aëroplane. For more than 4 years they have been experimenting with a gliding machine in the same manner as Mr. Chanute and Mr. Herring, and have devoted the most of that time to learning the art of balancing and guiding the machine in soaring flight. They made a number of original departures from the methods of other experimenters, in the first place by assuming a horizontal position, really lying face downward on the lower plane of the machine, and next by transferring the guiding rudder from the back to the front of the machine. To give a clear description of the Wright brothers' machine, and to explain the experiments made by them, would require the reading to you of the able reports made by Mr. Wilber Wright before the Western Society of Engineers, where he was presented by the President, Mr. Octave Chanute, on September 18, 1901, and again on June 24, 1903. These reports are well illustrated by photographic views, and are valuable text-books in the art of flying.

I will read an extract from Mr. Wilber Wright's report, published in the *Independent*, February 4th, this year, which describes their most recent and very successful attempt at flying.

"While carrying on these experiments our power machine was under construction. In dimensions it measures a little over 40 feet from tip to tip of the wings, of which there are a pair. Its length, fore and aft, to use a nautical phrase, is about 20 feet; and the weight, including that of the operator, as well as the engine and other machinery, is slightly over 700 pounds. We designed the machine to be driven by a pair of aërial screw propellers placed just behind the main wings. One of the propellers was set to revolve vertically and intended to give a forward motion, while the other, underneath the machine and revolving horizontally, was to assist in sustaining it in the air. We decided to use a gasoline motor for power, and constructed one of the 4-cycle type, which, revolving at a speed of 1200 revolutions a minute, would develop 16 brake horse power. It was provided with cylinders of 4-inch diameter, having a 4-inch

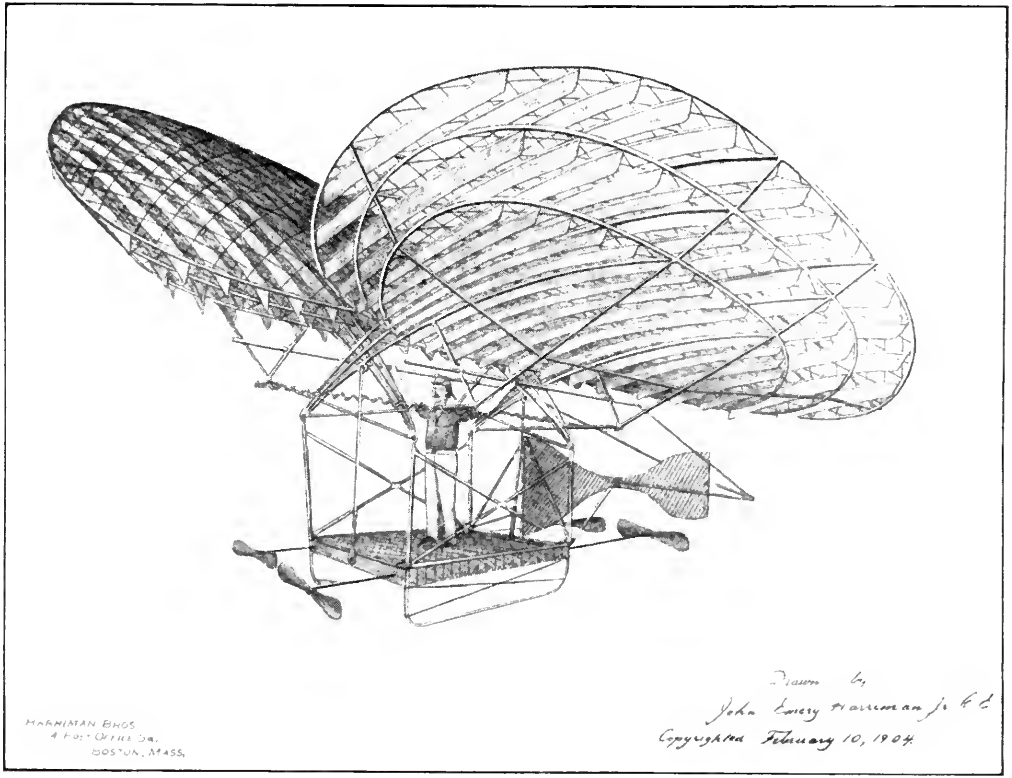
stroke and intended to consume between 9 and 10 pounds of gasoline an hour. The weight of the engine, including the wheel, is 152 pounds.

"We had calculated that the amount of mechanical power provided would be sufficient to maintain the machine in the air, as well as to propel it, the calculation being the result of gliding experiments which showed that when the wind was blowing at 18 miles an hour, the power consumed in operation was equal to $1\frac{1}{2}$ horse power, while with a wind of 25 miles an hour it represented 2 horse power, being capable of sustaining a weight of 160 pounds per horse power at the 18-mile rate. After the motor device was completed, 2 flights were made by my brother and 2 by myself on December 17th last. The apparatus had been placed on a single-rail track, built on the level, the track supporting it at a height of 8 inches from the ground. It was moved along the rail by the motor, and, after running about 40 feet, ascended into the air. The first flight covered but a short distance. Upon each successive attempt, however, the distance was increased, until at the last trial the machine flew a distance of a little over a half mile through the air by actual measurement. We decided that the flight ended here, because the operator touched a slight hummock of sand by turning the rudder too far in attempting to go nearer the surface. The experiment, however, showed that the machine possessed sufficient power to remain suspended longer if desired. According to the time taken of each flight, a speed varying from 30 to 35 miles an hour was attained in the air. We should have postponed these trials until the coming season, but for the fact that we wished to satisfy ourselves whether the machine had sufficient power to fly, sufficient strength to withstand the shock of landing and sufficient capacity to control. Winter had already set in when the last trials were made, but these facts were definitely established, and we know that the age of the flying machine has come at last."

It so happens that the machines and experiments that I have thus far mentioned were all made by civil or mechanical engineers of thorough technical and practical training, and in each and every instance they made a study of the problem before making experiments, which so well demonstrated their belief in mechanical flight that without hesitancy they have publicly proclaimed and published their conclusions without fears as to the final results.

Perhaps, before going further in describing what is being done in preparation for the aëronautic competition at St. Louis this summer, it would be fair for me to tell how I have become interested in the subject. In the first place, I have had the opportunity while

engaged in engineering to watch and study the flight of the American vulture, pelican, flamingo and sea fowl on the coast of Texas, hundreds of half-tamed sea gulls at the docks of Seattle, the broad-winged hawks near Lake Champlain and the large fishhawks among the islands of Penobscot Bay, Me., and in all instances I have been greatly impressed with the ease and grace of the slow flapping of the wings and the ability to soar through space. I have noticed particularly that at the same time with the downward flap of the wings there seemed to be a voluntary rise of the body of the bird, and as the wings were raised again the body seemed to drop slightly. It was this movement that inspired me to try to design a machine wherein the weight and muscles of the operator should assist in opening the wings on the upward stroke, and the release of that weight and power, by his jumping slightly and transferring it to the wings, should assist in the downward stroke, and my study resulted in the design here shown in perspective. This movement alone, to my mind, would reduce to a minimum the extra mechanical power necessary to flap the wings; and it is one of the principal points of my *design* here open to your inspection. It was shortly after this, while studying what had been done by others, that I found, in the library, what to me seems one of the best descriptions of flight published, namely, "Animal Locomotion and Aëronautics," by J. Bell Pettigrew, F.R.S.E., which I have already mentioned as being published in 1874; and it was the last sentence I have already repeated that gave me the assurance to hold to my belief, namely, "In the aërial machine, as far as yet devised, there is no sympathy between the weight to be elevated and the lifting power, while in natural flight the wings and weight of the flying creature act in concert and reciprocate; the wings elevating the body the one instant, the body by its fall elevating the wings the next." The downward flap of the wings would be assisted by springs underneath, of a tension about equal to the balanced weight of the body of the machine and operator. Next, in the design of the wings I would form double trusses, to pivot and cross each other, with the car suspended from the overlapping interior ends, which would have a tendency to raise the outer ends of the wings. The edges or circumference of the wings would be connected with the trusses and all would be held together by cross-cord bracing. From this network bracing I would suspend a series of parallel flaps that would close as the wings moved downward and open as the wings moved upward. I would use 2 or 3 wings on each side, one above the other, with a spread, when open, of about 36 feet from tip to tip. The length, from front to back of wing, would be about 18 feet, but



HARRIMAN'S AËROMOBILE.

it would not be entirely covered with the hanging flaps, as I would leave a space between the front and back part to increase the stability and safety of construction. To my mind, it would steady the machine.

I would follow the design of Wright and Chanute in making the wings convex on the upper side and concave below, with a curve in height equal to about one-ninth of the distance from the front edge. I would first try a gasoline engine of about 6 horse power to raise and lower these wings, and would use another engine of about 6 horse power to revolve propellers in front and back of the machine for pulling and pushing it ahead. I cannot believe otherwise than that a valvular wave wing will prove much more efficient than a horizontal revolving propeller in raising the machine, but I should not count on the flapping of the wings to assist very much in the forward motion, but would apply vertical propellers as already described. I would also attach an overhead center wing or canopy to act as a parachute in holding the body of the machine up while the wings are ascending. By this design the weight of operator, car and motive power would be in about the center of the machine and quite a little below the center of gravity, making the machine act as a parachute in case of accident to the propelling mechanism. The weight of this entire machine should not exceed 600 pounds, including the operator, and the cost should not exceed that of an automobile, say $2500.

I believe in flexible wings rather than the rigid aëroplane, as it can better adapt its surfaces to the variable wind pressures. After good headway was once gained there would be no need of further flapping, as the vertical propellers would force the machine through and on the air the same as a rigid machine. The Chanute, Wright and Lilienthal machines slowly glided downward through the air without motive power on a grade of about 15 per cent. It is therefore shown that in every 100 feet traveled, at even a slow rate, it is only necessary to gain 15 feet in order to maintain a horizontal line of travel, while under speed the drop per 100 to be overcome is a mere trifle, and in fact, by the proper inclination of the machine, a rise may be made. The rise and fall of the machine are directed by the operator's changing his position forward or backward, and the turn in direction is made by his shifting his weight to the right or left.

It seems to me that the problem of the mechanical flying machine has already been sufficiently solved and demonstrated to warrant immediate attention to it as a legitimate proposition for progressive business men. There is no more alluring and universally

attractive commercial enterprise before the public to-day for promotion, and when people are brought to realize and believe that this wonderful feat has truly been successfully done here in our own country first, by two conservative Americans, the Wright brothers, of Dayton, Ohio, they will wonder why this problem had not been properly attempted before; realize, from what has already been demonstrated at a cost of less than $2500 for 1 machine, and from what will be seen again by the public in a few short months at St. Louis, that the very first attempt at operating an aërocurve or aëroplane flying machine with modern mechanical motive power attached, bearing an operator, succeeded! Not such a wonderful feat after all when viewed from a mechanical standpoint; no unseen parts or movements, no intricate mechanism, no delusion, but reality.

As soon as the public is relieved of its skepticism and the individual investor is given an opportunity to see and know that mechanical flight is not an idle dream or cranky notion, then those who blindly undertake its imitation, regardless of future investigation or knowledge, will possibly make better or worse attempts at reproduction than the true investigators have made in development. It is a problem also open to those who can afford, and who believe in, scientific research and process, regardless of the pecuniary return that may be derived from the successful use and manufacture of the machine. When such men as Prof. Elihu Thomson, Alexander Graham Bell, Emile Berliner, Hiram Maxim, Langley, Chanute and other well-known scientific men give this problem their serious study and attention, with the indorsement of practical men like Mr. Munn, of the *Scientific American;* Colonel Church, of the *Army and Naval Journal;* Mr. Merrill, of the New York *World;* Mr. Brisbane, of the New York *American;* Mr. Walker, of the *Cosmopolitan;* Charles Francis Adams and other well-known Americans, does it not seem somewhat unwise for the non-investigator and non-believer to criticise these endeavors?

One of the greatest events and attractions that the world ever knew will be the aëronautic competition at the St. Louis Fair, open from the first day of June to the first day of October, over an L-shaped track some 30 miles in circuit, for a capital prize of $100,000 and $50,000 in minor prizes. The course will simply be marked out by 3 captive balloons.

Unlike the railroad, the thoroughfare, the open plain, the river, the lake or the ocean channel, the airship or aeromobile will not be confined to grades and alignment. For the flying machine there will never be expensive rights of way to build, protect and maintain, no regular confined channel to follow, buoy, light and map. The direc-

tion and elevation above surface are free from obstruction, no matter which way one may travel above sea or land. The air is the only universal highway that leads anywhere and everywhere. It connects all nations, seas and lands alike, without break or obstruction, day or night, and the elemental changes will not be many or so difficult to overcome as those on land or water.

The cost of evolution and construction of the flying machine will never be as great as that of the steamboat, steam engine or electric car or the more recent automobile, and in the near future the flying machine should be a familiar sight.

FERROINCLAVE AND CORNELL'S PATENT DOVETAILED LATH.

By H. C. Harrower, Member of the Engineers' Society of Western New York.

[Read before the Society, May 3, 1904.*]

I was much interested in Mr. Cobb's article under the title of "Ferroinclave," published in the Journal of the Association of Engineering Societies, for January, 1904. It struck me as another case of history repeating itself, as the lath there used seems to be a reincarnation of Cornell's patent dovetailed lath.

When I entered the shops of J. B. & J. M. Cornell, in New York, in 1872, they were the largest workers in structural and ornamental iron work in the country, and, among other things, they did a very considerable business in this lath. It was manufactured under their own letters patent, and had been for 15 years or more.

This lath was made from sheets of No. 24 or No. 26 sheet iron, which were passed through a special corrugating machine, which produced a finished sheet of lath 8 feet long and 2 feet wide, about $\frac{1}{2}$ inch thick from out to out of corrugation. These corrugations were $\frac{5}{8}$ inch across and the sides were recessed back, forming a dovetailed section. The result was a lath with a perfect clinch. It was used very largely by the Messrs. Cornell for partitions in fireproof buildings.

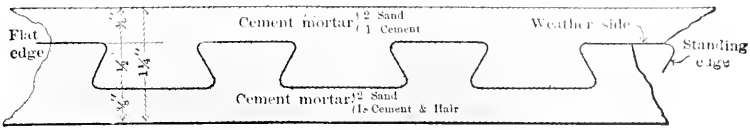
In partition work, the studs were made of 4 x $\frac{3}{8}$-inch iron, plugged on both edges. These were set up with the necessary door openings framed in. Then the sheets of lath were placed against the studs, the holes punched through for the plugs and the plugs riveted down. In a similar way the lath was used in ceilings.

Of course a man of Mr. Cornell's mechanical ability would see many other uses for the material, and among the rest he used it on a skeleton frame for mansard and deck roofs. After the Boston fire the firm did a large business in the rebuilding, and I recall two buildings, where it was used in the roof. These were the Transcript Building and a building for the Sears estate, on Summer Street, near Washington Street. Both of these buildings had mansard and deck roofs. Both were framed up with light beams and the whole covered with the dovetailed lath. The mansards were then slated and the decks covered with a coating of Neuchatel asphalt, about 2 inches thick, and the mansards were plastered on the inside.

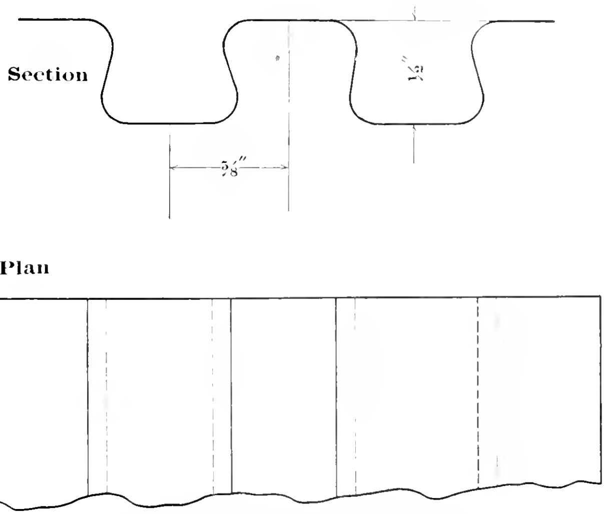
* Manuscript received June 2, 1904.—Secretary, Ass'n of Eng. Socs.

Both of these buildings were finished before I went to Boston, in 1874, to take charge of the branch office, but I have good cause to remember them, for I had a great deal of trouble keeping them tight, leaks being caused by the cracking of the asphalt due to the expansion of the iron.

My principal work in Boston was in the construction of the Milk Street building of the Mutual Life Insurance Co., of New York. This building was very expensively finished, being strictly



Section of Complete Ferroinclave Roofing



Cornell's Patent Dove-tailed Lath

fireproof, and all the interior finish being of marble or iron. All the partitions were made as above described. After the building was enclosed, it was found that the 200-foot tower was settling badly, and it was determined to lighten up the floor filling around the tower as much as possible. The old style brick arches had been put in, except in the tower itself; and drain tile of varying diameters was used to fill in the haunches, where the arches were in place.

In the tower itself we put in an extra set of light beams,

blocked up from the regular floor beams, and on these we laid the corrugated lath with a light filling of cement under the finished floor. Shortly after this time, cheaper forms of lath came into use, such as the Bostwick and stiffened wire, and when I left the Cornells, in 1884, the use of their lath had largely diminished, and I am unable to say whether it is still made.

For a number of years after coming to Buffalo, I had a sample of the lath in my office, but it has disappeared and I have had the small sketch, shown herewith, made from memory.* You will notice that it seems to be identical with Mr. Cobb's material, and that, in the Transcript and Sears estate buildings, we used the lath in the same way that Mr. Cobb used his material.

I trust that you will bear with me in these somewhat crude remarks, as Mr. Cobb's article was like a call from an old friend.

DISCUSSION.

Mr. H. F. Cobb.—United States Patent No. 117,384, dated July 25, 1871, and granted J. B. Cornell for fire-proof roofing, covers a roof construction composed of corrugated iron with a section like the standard corrugated iron, or having a section somewhat like ferroinclave. To this a slate, or imitation slate, is attached with screws or copper nails. This slate rests directly upon the corrugated iron upon the upper side. Upon the under side the corrugated iron is left uncovered, or, if it is shaped somewhat like ferroinclave, it may be plastered.

Mr. Cornell's claims are as follows:

A fire-proof roof formed of slate C, and corrugated metal sheet A, applied to a building in the manner specified.

Second. The slate C, sheet A, and plastering E, combine and apply all and for the purpose specified.

The writer cannot see that there is any similarity between Mr. Cornell's old invention and Mr. Brown's invention of ferroinclave, except in the fact that one of the sections of corrugated iron advocated by Mr. Cornell has a dovetail shape and is used to hold plaster on the under side. Ferroinclave roofing is a reinforced concrete construction, while Mr. Cornell's is not. In the Cornell construction the corrugated iron will soon rust entirely away and permit the whole roof to fall. Ferroinclave is entirely protected by

* For comparison, Fig. 1, of Mr. Cobb's paper, from the Journal for January, 1904, showing section of the ferroinclave lath, is reproduced herewith, by courtesy of the Brown Hoisting Machinery Company.—Secretary, Ass'n Eng. Socs.

Portland mortar and will last indefinitely. Mr. Cornell must make butt joints between the ends of his sheets, where ferroinclave sheets, with tapered corrugations, will fit into one another at the ends and so make the surface continuous.

Mr. H. C. Harrower.—I am not familiar with the details of the J. B. Cornell patent, but I do know that the material manufactured under it was not standard corrugated iron, but was in fact identical in shape with the material that Mr. Cobb shows in his drawings illustrating ferroinclave. It is also a fact, that while in mansard work it was used as Mr. Cobb states, on deck roofs it was used in practically the same way as that in which Mr. Cobb uses his ferroinclave. One of these roofs, that on the Transcript Building in Boston, came under my personal supervision, as stated in my paper. Here the material was completely imbedded, having two inches of asphalt on top and one inch of plaster on the under side.

Mr. Cobb may be right as to the claims of the original patent, but Mr. Cornell evidently found other practical uses for the material, and among them was that claimed by Mr. Cobb as originating with ferroinclave. Mr. Cobb is in error in his assertion, that Mr. Cornell made butt joints. On the contrary, they were lap joints, one end of each sheet having the corrugations opened enough to allow the next sheet to slip in about two inches. After the sheets were corrugated, they were placed on a special table, and a mandrel, shaped to fit the corrugations, was forced into one end, enlarging it for the purpose named above.

ON CONTEMPORARY TECHNICAL EDUCATION.

ADDRESS OF JOHN R. FREEMAN*

ON BEHALF OF THE ENGINEERING SOCIETIES AT THE

INAUGURATION OF PRESIDENT CHARLES S. HOWE. CASE SCHOOL OF APPLIED SCIENCE, Cleveland, Ohio, May 11, 1904.

Mr. President:

As delegate on behalf of our Engineering Societies, I must explain that these also are Schools of Applied Science. They are the more attractive to students since they hold no examinations; all studies are elective and voluntary; one recites only when he feels like it; and the social element is pre eminent.

Into this university of the Engineering Societies, we hope to receive all of your graduates and to retain them as fellow-students and warm friends to the end of their lives.

APPRECIATION OF THE TECHNICAL SCHOOL.

In speaking on behalf of the engineering profession, my first words must acknowledge our great debt to the technical school and that this debt is increasing from year to year. Our members are coming to be recruited in an ever-increasing proportion from the technical graduates ([1]).†

From the researches conducted in your laboratories, we obtain much of our most valuable engineering data.

Our best books of reference for the practicing engineer are nearly all prepared by the professors in these technical schools ([2]).

The strongest foundation for a country's future industrial and commercial welfare is to be found in Schools of Applied Science, well equipped, guided by men of broad mental horizon. This is scantily appreciated as yet by the mass of strenuous Americans, but it has long been clearly seen by the Germans, and is beginning to be seen by the English ([3]).

The cost of duplicating the land, buildings, equipment and endowment of the largest and most complete technical school in the United States is little more than half the cost of one of the latest battleships, and the running expenses of the largest technical school per year are less than those of a battleship ([4]). The Technical School has a use no less important than the battleship in the "first line of

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* Vice-President American Society of Mechanical Engineers; Member Board of Managers, Association of Engineering Societies.

In compliance with the invitation received, and, at the request of the Chairman, Mr. Freeman represented the Board at the inauguration of President Howe.

† Footnotes. See end of paper.

national defense." The time has already come when the commonwealth and the nation should contribute more liberally to the burden of its support and help it to ever broader usefulness. With the increasing numbers of students and with the rapidly increasing cost of laboratory facilities needed for the best training, the need of funds is greater than private munificence can be relied upon to meet. The demonstration of their great value to the prosperity of the state is already complete ([5]).

In the re-awakening of the old spirit of commercial adventure in foreign lands, we must to-day base our hope of success on superior excellence and economy of manufacture and in the calling of our engineers to foreign lands.

The growth of our cities is laying a burden of new and larger problems on our departments of public works, a burden which only those trained in the Schools of Applied Science can carry wisely and well.

The business man, when he comes to see these matters clearly, will urge again and again a generous support to Schools of Applied Science by city, state and nation when private munificence falls short.

These schools need, as managers, the strongest men that can be found, the men of broadest horizon, the men that can arouse the noble ambitions of young men toward advancing the state of an art and that can impart the spirit of joy in work.

APPRECIATION OF THE TECHNICAL GRADUATE.

For twenty-five years I have been observing the increasing respect paid by our industrial leaders to the training gained in the technical school. The technical graduate himself has come to better understand his own limitations, and his need of a course outside, under instruction from the foreman and the mechanic. The man of business is coming to understand that there are "first," "seconds" the "thirds" produced, that some excel in judgment and some in skill, and that it is not the mere fact of being a technical graduate that brings success, but that, given inborn executive ability, the training of college or technical school gives to its graduate a tremendous advantage over the man of equal native force who has not this training.

Twenty-eight years ago the finding of openings by my own fellow graduates was difficult and slow,—not a third of our men found openings of fair promise within the first six months; the average "captain of industry" did not then know just what a technical graduate was, or what he was good for.

We then listened to prophesies that the annual output of engineering graduates would soon overstock the market. To-day, notwithstanding that, during the past quarter of a century, technical schools have multiplied on every side and that classes in many of the older ones have increased fourfold, the output is quickly absorbed. The department head in one of our largest technical schools has told me repeatedly that in each recent year he has applications from managers of important works for double the number of his graduates, and it is said that certain large and progressive concerns send an agent around the schools in January to select from the brightest of those who are to graduate in June.

The mere register of the occupation of the graduates from any leading School of Applied Science is a most eloquent commentary on the commanding influence of these schools.

Twenty-five years ago, among managers of works, I heard much about the good *practical* man and his superiority to the theoretical college graduate; to-day it is coming to be generally recognized that the *good* practical man is the one who has graduated from a technical school and who has then been seasoned by a few years of experience in bumping against corners of construction, and the technical graduate of proved business ability is in special demand.

The Technical School, the School of Mechanic Arts, and the Mechanics Correspondence School, each has its special and distinct value in our industrial life. We should make the technical school attractive to the brightest minds, and should look to it for our industrial and commercial leaders and for the best custodians of the public health, of our water supplies and other public works.

In order to get the most out of the existing technical schools, let us keep in mind the limitations within which they can do their most efficient work, and the fact that not every kind of work will be best done by a technical graduate. The students found without promise of final success should in all kindness be allowed to depart and not hold back the best.

Doubtless a man may give lines and grades as well, may drive an engine or detail steel work better, if his four years of early manhood have been spent gaining this dexterity and skill outside the technical school. The late Col. T. J. Borden, a sympathetic thoughtful man of 40 years' experience as manager of large industrial works, and himself a technical graduate, told me that for many years he had been observing that a faithful uneducated laborer would in general keep a more correct tally sheet of the unloading of a cargo than the bright high-school graduate whose thoughts were flying off to other things; that a large factory

engine would be run with better attention and fewer breakdowns by a graduated stoker or oiler than by an expert machinist, who was liable to be scheming out improvements and to have his mind busy with something other than the mere operation of this machine; that often the best routine work was done by a man who was not capable of anything very much better.

The young man who is to follow a narrow routine through life will not have much added to his efficiency, as a machine, by the long elaborate course of the technical school. For those constitutionally deficient in ambition, or for those unfortunates who can never comprehend the art of getting on in the world, these four extra years are ill spent at school, but there are plenty of young men for whom this training of the technical school is the best possible training, and there is plenty of opportunity for a larger number of these men than all of our present schools can graduate.

Men cannot be shaped on the interchangeable system of the American Machine Shop, each will be a "special," and, as already remarked, there will be produced "firsts," "seconds," and "thirds," but fortunately the demand for all types and grades exceeds the possible supply for years to come.

Among the graduates, some will possess that rare faculty for which "initiative" is the phrase of the day, and among these there will be some who will possess that quality of balance and judgment, and attain such knowledge of men, that they will become great leaders, the captains, will establish their own industrial works or be called to the $10,000 positions which are always so hard to fill right. Others, without this business insight, but perhaps more learned and more skilful in engineering, will design machines and bridges, supervise factories, become the lieutenants and fill the $4000 and the $2000 positions, and a still larger number will do noble work as the sergeants, corporals and privates and be made better men by the broadening of their minds.

The training of no school can make the square peg fit easily in the round hole, and, out of a hundred boys, but few are born with the ear of a musician or the eye of an artist, or with the observing, inquiring, ingenious, imaginative mind, which schools can stimulate but cannot create, and without which conspicuous success in constructive engineering is impossible. But for the young man so fitted by nature, a technical school of broad scope and high aim is a royal road.

A ROYAL ROAD.

The old statement that "There is no royal road to learning" is untrue. The man of affairs has come to understand that *the*

technical school is a royal road to learning, a shorter road, an easier road, through a more beautiful landscape, and in equal time attaining a broader outlook.

A man with the earnestness and persistence of John Brashier, the strong purpose of John C. Hoadley, the rugged common sense of Edwin Reynolds, the strong, kindly heart and quick intelligence of John Fritz, or the genius of Edison, may reach an equal height by a longer and more arduous road, and, like the athlete, increase his strength and harden his endurance in the greater effort; but the royal road of the technical school, in its four years, may, from its small group of a hundred, gathered part by chance and part by process of natural selection from more than ten thousand school boys, bring perhaps ten or twenty to the point that otherwise not more than one or two or three could hope to reach in twice these four years.

The technical school is not exclusively for the brilliant man. Much of the world's best work is done by the man of slow-moving intellect, to whom the good Lord has given the greater treasure of persistence, of steadfastness, with enough of imagination to feel what is concealed within the cloud on yonder difficult and distant hill.

There is danger in relying upon lectures and reading for teaching, and upon written examinations for measuring up a student and his fitness to continue on his four years' course. One of the greatest advantages of the technical school is found in its Laboratory method, for the reason that the personal, individual contact with the student daily in the laboratory gives an opportunity for helping the one who is slow to develop himself.

I have had perhaps twenty graduates tell me in familiar talk that the most helpful man to them of all the "Technology" professors was the lamented Holman. Why? First, because he was intellectually great and a noble man, and second, because he took pains to get acquainted with them and their individual needs, *in the laboratory.* The ablest professors should be brought into earliest possible contact with the freshmen in the laboratory.

THE OPPORTUNITY FOR THE TECHNICAL GRADUATE.

For a few moments past we have been considering the broader appreciation, by men of affairs, for the work of the technical school; let us for a moment review the causes of its great opportunity.

That the manufacture of power was the mainspring of the onward movement of the nineteenth century was made plain, perhaps more ludicidly than ever before, by that great engineer, whose re-

cent loss we mourn, George H. Morison, in his Phi Beta Kappa address at Harvard in 1895.

In the skilful application of manufactured power lies the great opportunity of the engineer.

The distribution and use of manufactured power are increasing by leaps and bounds in a way that few of us can see in perspective.

It moves a thousand cotton spindles guided by a single hand, with the power of more than a thousand horses, it ([6]) draws your "20th Century Express," large cotton factories in Montreal are driven by a waterfall nearly a hundred miles away, the power of Niagara rends the strongest chemical affinities. The chariot, as made in Cleveland, is horseless, but it is propelled by the power of 24 horses, all generated in a little space and derived from a harnessed explosion. In another part of your city, the most delicate and accurate engraving that the skill of the world has known, an astronomer's circle with markings correct within less than a second of arc, may go on in solitude as a result of a laborer shovelling coal under a steam boiler. To-day there is far more steam power used in Lowell than water power, and in your city of Cleveland the power manufactured from coal far exceeds that of the greatest single development of water power in the world ([7]), Niagara not excepted. The General Electric Co. had on its books, on Jan. 31, 1904, undelivered orders for steam turbines of an aggregate power of 350,000 horse power, an amount three times as great as the present total generation of power from Niagara and nearly half as great as the total water and steam power combined, in the six New England States, found in the census of 1880.

With the aid of unlimited power, work is performed in a larger way and with greater rush, and with this comes the greater need of executive ability, of captains and corporals of systematic, observing habit, equipped with the tools and training of the technical school.

This is a transition period, and never was there such opportunity for the trained engineer. Mechanical production must supply the natural increase due to the growth in population, and replace machines worn out by service, and even new machines by something newer. Here in Cleveland your horse cars were not worn out when the cable car replaced them, your cable railways were not worn out when the electric car came in. Not only the equipment, but the shop that makes it, must largely go into scrap.

Two or three years ago one of the leading engine builders of the world began on new shops in a city on the Great Lakes, the largest of their kind, designed for building engines of the most massive

type. Hundreds of thousands of dollars were expended on these shops and their heavy machine tools, but, before these shops were occupied, customers were inquiring, not for engines but for steam turbines.

The leading pump builder of America began two years ago on new shops near New York, these also to be the largest in the world; the plans had been matured by years of study, for building pumping engines of the ordinary reciprocating type. Before these shops are ready for occupancy, the old and simple and inefficient type of centrifugal pump is suddenly so improved as to threaten a revolution which may profoundly change the type of shop equipment demanded.

A maker of valves and pipe fittings, a concern which had kept steadily up-to-date for more than a quarter of a century, started, about two years ago, to supply its expanding trade by a factory on the shores of Long Island Sound, designed to employ at first 2000 and later 4000 men. The plans were matured with rare care and judgment. First, their man of greatest skill in shop methods plans for his various machines and lays out his floor space. Next, the skilled mill engineer makes plans to house that floor space in. Next, an architect, of national reputation for his inborn sense of beautiful form and graceful line, models the outlines of exterior wall and windows and roof. Machine tools of latest design had been purchased, apparently everything had been provided for, when, just as the roofs are on, the successful demonstration of a new kind of tool steel, which permits of far deeper and more rapid cuts, calls a halt and requires a radical change.

All this is recent and the end is not in sight. Seventy-five years ago, when Cleveland was a frontier village, within the memory of a few men now living, the dry dock in the Boston Navy Yard was the most monumental piece of engineering construction and the greatest single work of internal improvement yet completed within the United States, and the total of manufactured power in the United States did not equal the output of one of the large power stations of to-day.

It is only forty years since the first distinctive general School of Applied Sciences, or Institute of Technology, in this country, began, after years of patient explanation and pleading by that lovable, eloquent, prophetic, noble man of science, William Barton Rogers, and how profoundly it has influenced the whole course of higher education.

Not long ago I had a letter from a fine old gentleman of Boston who, educated in France, in his day and generation had been the

best educated engineer in America and who began his practice on the earliest steam railroad, under the great Stephenson, one whose pleasure it had been through a life of uncommon length to follow engineering developments in varied lines. This man, who had seen the railroad born, the use of electricity and a thousand other marvelous results of scientific study, wrote of *the greater* opportunity of the young engineer of to-day!

Although the lines of work formerly recognized as engineering may be crowded, there are, on every side, unworked fields in which the trained engineer, possessing business ability, be he builder, sanitarian, chemist, mechanic, or electrician, can introduce system, discover causes, lessen cost and improve the product and find for himself a competency and joy in work.

A PLEA FOR BREADTH OF CULTURE IN THE SCHOOL.

The other speakers to-day are presidents of colleges, educators of wide experience and national reputation, and it savors of rashness for me, in their presence, to venture opinions upon the aims and methods of a technical school, but during my twenty-five years of taking on one or more technical graduates in almost every year, and trying, through them, to keep in touch with the schools, I have so often found what has seemed to me a misapprehension among students, friends and patrons of technical schools, that, to an audience of patrons, teachers and students, a few words, from the standpoint of a business man and practicing engineer, may have some interest.

Why do we not find the greatest prizes of the industrial works and of civic administration going *more* often to the technical graduate? The commercial department pays a better salary than the engineering department. We have all seen plenty of examples to prove that technical training can be of itself an aid rather than a bar to commercial success.

Have our men got too narrow a training in the technical school?

Within the past week I have chanced to hear two heads of concerns, employing many scientific men, say in substance that the old academic education fits better for the position where one deals with men, or for the $10,000 position, while the technical school fits better for the position that deals with materials, or for the $4000 position, and I note that sons of my old classmates are being sent first to Harvard or Yale or Dartmouth for *four* years and then to "Technology" for a *two* years course in science.

Six years time, from 18 to 24, is more than the average young

man can afford to spend at school. It brings him into the works too late. When we more fully appreciate that education, rather than information, is the true aim of the technical school, then a broad education and sufficient information can both be given in a four years' course.

Can we not give a better education to the great majority of our students and plant in them thirst for information, by doing fewer things more profoundly and putting more emphasis on the personal element?

Is not one great captain of science or industry, like Pasteur, Kelvin, Ericsson, Bessemer, Westinghouse, Brush, Mills or Alex. Brown and a hundred others, worth more to his country and his neighborhood than a roomful of the very necessary and useful sergeants and corporals of science and industry?

Cannot our school do the most good and best serve all, and best stimulate the ambition of all, by trying to fit men for the position of captain; and, if the man, skilled in the application of science, has also executive skill and such knowledge of men that he can negotiate, convince and arouse men, will not he have a wider opportunity to do good and to advance the state of the art and the public welfare; and shall we not, by addressing our teaching to the highest grade, thus produce more of the $10,000 men and at the same time better $4000 men?

In separating students into many courses, is there not danger of splitting things too fine? Have the schools not already gone too far in specializing for the undergraduate?

It is a matter of slight importance to the builder of machines or of water works whether he takes the course in mechanical engineering, civil engineering, or general physics, *if he is fortunate in his teacher.*

The chief function of the Technical School is not the filling of a man's memory with formulas and with knowledge of how everything is made, but rather is the training in methods of thoughtful research, of teaching how to put the question and where and how to find the answer, of how to set traps for our own unconscious errors, how to save time by understanding just what degree of precision is necessary to the case in hand, how to measure with certainty the limits of the ever-present error, and above all to develop and strengthen a warm, enthusiastic, undeviating love for the truth.

In my own college days, I did not have it made plain, and I failed to grasp the fact, that perhaps the greatest opportunity of college life is that of coming to better know one's fellow-men, and it is in

failure to appreciate this, more than in any other one feature, that the professional school has failed in comparison with the older colleges. In the protest against the old education, exemplified in the early development of the Massachusetts Institute of Technology and other similar schools, the pendulum swung beyond the center, and the value of the social idea was for a time not appreciated. To many of us there was lost the inspiration and broadening, the deeper understanding of humanity that may come from entering into the daily life of the ancient civilizations enough to understand that human nature is much the same through three thousand years. We missed that focussing and sharpening of the wits which comes from taking time for the discussion of current events with our fellows.

We had a professor who wisely read to his class those verses on The Deacon's Masterpiece, "that was built in such a logical way," as typifying the ideal machine. McAndrews' Hymn may teach a deeper lesson. The man should be led to find inspiration in his machinery, while in the technical school.

A few weeks ago, in Chicago, I sat beside a classmate, a former "grind," now a successful man of business, at a gathering of the graduates of one of our largest technical schools. Said he, "We were brought up wrong in being taught to spend so much time on our studies; we practiced a false economy in being too thrifty in our earlier years." We were too late in learning that opportunity, sustaining power and a stimulus toward success, came more from a wise good-fellowship than from high scholarship, and that the art of being what in your terse Western phrase is called "a good mixer" was an art well worth time, money and paternal advice to cultivate. It is by giving the technical graduate a wise start in this direction that he will ultimately come more often into the larger opportunity and the higher salary of the commercial end.

This social feature is, in the final analysis, the chief value of the engineering societies. Although papers are presented in which one engineer so presents his experience that a hundred others may find each his own course more clear in attacking a similar problem, although one may hear presented in an evening hour the results of experiments and research that have cost a year of toil, all so summed up in a few lines of formulas or constants, that a repetition of this labor and expense is saved to all who follow, and although the master mind may publish in the transactions a study upon difficult and disputed points that will lighten labor or save mistakes to many of his fellows; yet, after all, the pre-eminent usefulness of the Society of Engineers is in the bringing of men into

personal relation, inspiring the young man by personal contact with the man who has done things, giving the older men a chance to size up the growing young men; and, among equals, it removes the bitterness to personally know our successful competitor and to know that he is a good, honest man.

If it be asked what suggestions can be offered to his friend, the teacher, by a practicing engineer, who has for twenty-five years enjoyed taking "green graduates" and trying to help them on their post-graduate course, I venture the following:

Dwell on the principles of research, fill the student mind with a comprehension that the school is not so much for filling his memory with information as for teaching the scientific method.

Give more attention to the principles of writing reports in clear, exact and vigorous English, to measuring the exact meaning into every sentence. Teach what may be called "commercial rhetoric," bringing the result quickly into the view of the busy man and seeking to so arouse his interest in the opening paragraphs that he will continue reading instead of laying it aside for the leisure hours that may never come.

Emphasize the need, in the practical world, of "getting there" on time.

Recognize that a judicious "cramming for examination" is legitimate, and that how to do it with the least internal friction is a most worthy subject of instruction. In closing business contracts and in expert work, it is a much practiced and most useful art.

Direct attention to the conditions necessary for obtaining a maximum output from the human machine. How seldom a man gives, to his own body, the same care he would give to that of a $1000 horse! Long hours under stress in emergency are easy if the man knows how to avoid fatigue through variety, and has the will power to practice what he knows.

Probably there is no better way to save time and cultivate judgment than by practice in quick estimates between limits. What does that stone weigh? Not more than 6 tons, not less than 4. What will that casting cost? Not less than $50, not more than $100. If the owner asks the cost of repairing the tangled smash-up of ten minutes ago, the young engineer can give him almost instantly an estimate that may serve his purpose, and be correct, if he states it between limits, as, "not more than $10,000, and not less than $1000." Twenty-four hours later, he may be able to state it as not more than $5000, and not less than $4000.

Urge upon your colleagues the fact that they owe it, to their fellow-citizens and to the loyal intelligent public that supports the

school, to promptly and continually translate the story of the latest discovery of abstruse science down to the understanding of the well-educated non-technical man.

Stimulate the interest of the students by continually bringing before them the results of the latest research and of what is being found out in other departments of the school.

Recognize the fact that these four years' time, with their attendant expense, are too valuable to be devoted to the attainment of mere manual dexterity. This can be more cheaply learned in the field or workshop than in the school. Do not shrink from turning out graduates who will be strong on theory, while perhaps weak on practice. They can get their practice outside after graduation, and perhaps under the quickening influence of some shortlived ridicule by the routine workman. The sound foundation of mathematics, the facility in handling and transforming difficult equations, the mental grasp of difficult considerations, so as to state them in the language of mathematics and quantity, must be acquired in the Technical School or the chances are they will never be acquired.

Finally, to the many students here, I can bring back no better word, from out the years since I left similar pleasant places, than to remind you how largely the success of a school depends on atmosphere and that every man has a share in forming public opinion; and to urge you to fill the student atmosphere with the fraternal spirit and with ideality,—ideality, with the love of thoroughness and with reverence for character.

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(1) Out of the latest 1000 condidates for admission to the American Society of Civil Engineers in the three grades, member, associate member and junior, about 75 per cent. have graduated from a technical school; in the American Society of Mechanical Engineers, this proportion is 60 per cent.; in the Electrical Engineers, 44 per cent. In each society the proportion is largest among the junior members.

(2) Out of a catalogue of 55 technical books brought out by a leading American publisher of engineering books during the past year, 75 per cent. of the whole were by professors, mainly in Technical schools.

(3) See Presidential address of Sir Norman Lockyer, President of the British Association for the Advancement of Science, in September last, entitled "The Influence of Brain Power in History," devoted to urging the British Nation to come to the support of its Technical Schools.

(4) COST OF A BATTLESHIP.

The approximate cost of the hull of a first-class battleship is....	$3,250,000
The engines, machinery and engineering stores cost about......	1,300,000
For the largest ships the cost of armor is about...............	1,750,000
For the largest ships the cost of armament is about...........	1,050,000
The supplies and general equipment about......................	100,000
Total cost of a first-class battleship about...............	$7,450,000

For a ship of the Vermont class of 16,000 tons displacement, with the latest armament and including designs and superintendence, the total cost may approximate	$8,000,000

The cost of maintaining such a ship in commission will be nearly 50 per cent. more than for the three ships as stated below, which are of 12,000 tons.

The report of the Secretary of the Navy shows that the cost of maintaining the three battleships, Alabama, Kearsarge and Wisconsin, in commission for the year ending June 30, 1902, averaged	$441,248
Current repairs	30,914
Total	$472,162
The foregoing includes pay of officers, crew and marines, and cost of stores, including coal, but includes no allowance for depreciation. If depreciation be figured at the moderate rate of 5 per cent. annually, having regard to wear, and to improvements rendering much obsolete, this adds per year nearly	400,000
	$872,162

COST OF A TECHNICAL SCHOOL.

Several of the leading schools of applied science are parts of great universities in which the accounts of different departments are so merged that it is difficult to separate the cost of plant and running expenses required for the courses in applied science.

The Massachusetts Institute of Technology is perhaps the most convenient example for present purposes, because of being almost exclusively a technical school. Its present site is on land of exceptionally high value for business purposes, because of surrounding developments; therefore, I will not include the full sum for which this land could probably be sold.

It is estimated that a suitable site could be procured for	$250,000
The estimated cost of replacing present buildings at present prices is	1,044,000
The total value of apparatus and furnishings, as estimated for insurance purposes, is	386,000
Approximate cost of duplicating plant	$1,680,000
The endowment or stock, bonds and real estate producing direct income is about	1,150,000
Total	$2,830,000

The number of students is 1528.

The annual expenditure last year in round numbers was as follows:

Salaries	$320,000
Fuel	25,000
Water, gas and electricity	7,600
Repairs	16,000
Printing lecture notes, catalogues, etc	14,000
Laboratory supplies and libraries	50,000
General supplies and maintenance	30,000
Miscellaneous	13,000
Total	$475,000

This amounts to an actual expenditure of about................ per student (including special students, some of whom take few studies and pay less than full fee). Reckoning the interest at 4 per cent. and depreciation on whole plant, buildings and furnishings, at 5 per cent. per annum, this adds about..	$311 91
making the total yearly cost per student...................... of which he pays a tuition of $250.	$402

(5) The generous support given by Michigan, Wisconsin, and California to their great State Universities, which are coming to be in large proportion schools of applied science, may indicate a better appreciation of this service to the State than is yet found in the legislatures of our Eastern commonwealths, or than is yet disseminated through the mass of their intelligent citizens.

In 1903, Michigan paid from the State Treasury for the support of the State University	$559,835.03
The State raises by general taxation in the average year for the support of the State University	394,625
and in addition makes special appropriations or draws from accumulated funds.	
Wisconsin raised by direct taxation for the support of its State University	289,000
and when the regular annual appropriation is found insufficient the Legislature makes special appropriation. The entire disbursements on account of the State University last year amounted to	771,053
The University of California has an income for current expenses for 1904-05 of..	659,808.96
of which sum nearly ⅓ is appropriated for departments in which engineering students predominate.	

The Case School of Applied Science is not assisted from general taxation, but depends for support only on the income from its endowment and fees of students.

(6) A locomotive engine of the type used in drawing the 20th Century over the New York Central portion of the route has, under test, shown a continuous development of upward of 1200 horse power, at speeds of from 40 to 57 miles per hour.

From a large type of locomotive, recently put in service on the New York Central and Hudson River Railroad, an indicated horse power of approximately 2000 has been obtained.

On the Lake Shore road, indicator cards, taken from fast passenger trains at one minute intervals for an entire trip where the speed over an entire division averaged about the same as for the 20th Century Express, namely, 54 miles an hour, showed an average of about 1000 horse power for the entire division. For distances of 5 to 10 miles, powers as high as 1500 to 1600 horse power have been obtained.

	Horse Power.
(7) The total amount of water power now in use daily by the works located at Niagara is not far from....................	75,000
In addition to this, there are now generated at Niagara, and transmitted to Buffalo and other points, not far from..............	25,000

	Horse Power.
The aggregate capacity of the generators installed up to date at Niagara is about..........	130,000
On the American side an additional capacity is being provided of perhaps	50,000
And on the Canadian site the contracts have been let for machines capable of generating about	80,000
In the city of Cleveland an approximate estimate, reasonably made up by Mr. Ambrose Swasey and Mr. Scovill, vice-president of the Cleveland Electric Illuminating Co., puts it at...........	50,000
for the total of the large electric power and electric railroad plants.	
At the 73 large factories in Cleveland, they estimate the power used as	85,000
In small factories, lumber yards, office buildings, etc., etc., probably	25,000
Total	160,000

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THE PRESENT AND THE FUTURE OF ENGINEERING ON THE PACIFIC COAST.

Inaugural Address.

DELIVERED BY PRESIDENT GEORGE W. DICKIE BEFORE THE SPRING MEETING OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST, MAY 26, 1904.*

Ladies and Gentlemen and Members of the Society:

WITH the hope that I might be able to help this Society in some of the problems that it will have to face in the near future, I consented, after a long rest, to again serve you as presiding officer at your meetings.

It is a great honor to be selected by one's professional brethren to be President of such a Society, and I appreciate to the full the confidence that you still have in my ability to serve you again in this capacity. It has come to be a custom in societies like this for the President, at the beginning of his term, to address the members of his Society on the general condition and future prospects of the profession that the Society represents; and, as the engineering profession in its various branches will best represent the varied interests of our members, I cannot do better on this occasion than to give you my impression in a general way on the present and future of engineering on the Pacific Coast.

I sometimes think that it has been unfortunate for the engineers who came to the Pacific Coast in the early days of its development that so much of their work both in the civil and mechanical branches of the profession had of necessity to be of a temporary character and executed under conditions and in localities that ren-

* Manuscript received June 30, 1904.—Secretary, Ass'n of Eng. Socs.

dered any extended knowledge of its character well-nigh impossible. If we could have a history of the engineering work carried out in California and Nevada during the 20 years between 1865 and 1885, it would be a remarkable record of daring work, and would lift into fame many names now almost forgotten. It is a great misfortune that the lust for gold overcame all desire to preserve a record of the work done by the men who made the search for the precious metal possible. Even the destruction of some fair parts of our State required engineering work of the most daring character in impounding water (the great agent of destruction), carrying it through mountains and across deep gulches, sometimes with the water under enormous heads, in order to bring it to the great beds of gold-bearing ground, where its force would sweep the accumulations of ages into the great sluices arranged by the miner to catch the golden treasure that Nature had locked up in mountain safes by the gentler acting of the same power that the engineer employed to crack these safes of hers. But Nature did no deep mining to get that gold that she locked up in the soil—that soil had been washed down from the mountains, and the gold had come with it and man must find its source, so he must mine to find the strata that contains the precious metal. The engineer must provide the means to do so. Hoisting engines and pumping engines and many other machines must be devised to explore the deep storehouses of Nature and bring the treasure to the surface, and some of the greatest works of this character were carried out during the seventies on the great Comstock Lode. Then engineering skill and chemical science had to combine their resources to extract from this precious ore the treasure it contained, and, although this work was all done within the life experience of several of our own members, no true history of it can ever be written.

This blank in the most interesting period of engineering history on the Pacific Coast is, I think, a great misfortune which can never be remedied; and, in order that it may not be repeated in the present and future work of the engineer here, the members of this Society should tell each other what they are doing and how they are doing it at such meetings as this, so that the record may be complete, and the great communities that are to occupy this land that we are trying to make pleasant and comfortable for them may know to whom they are indebted for the many conveniences of civilization they will find here, provided through the skill and labor of the engineers who are now making things ready for them.

Much of an engineering character that is going on now on the Pacific Coast is unknown to the profession outside of those within

sight of the work being done or directly concerned in the financial or engineering problems involved. The result of this is that the engineer and his work on the Pacific Coast are unknown to the world at large. In the transactions of the great engineering societies, or in the magazine literature of the profession, we can study the great engineering works being carried out in other parts of the world, but we do not appear to find time or opportunity to tell the world outside what we are doing here to utilize the vast natural resources around us. In this we are not dealing honestly either with ourselves or our professional brethren in other lands. While a number of us may be members of the National Engineering Societies, our isolated position makes it impossible for us to attend their meetings except perhaps once or twice in a lifetime, and in consequence we cut no figure in their transactions. We must therefore make the literature that will represent to the great world outside the work done by the engineers of the Pacific Coast. At present we do not know what we have done, what we are now doing or what we expect to do. It is therefore of the utmost importance to ourselves and a duty we owe to those who are to follow after us, that we meet together, from time to time, so that we may get to know each other, and compare notes as to what we are doing, thereby helping one another in the solution of the ever-present difficulties in all engineering problems. "As iron sharpeneth iron, so a man sharpeneth the countenance of his friend."

To my mind, one of the best reasons why the engineers of the Pacific Coast should maintain and foster a strong local Society embracing the different branches of the profession lies in the fact that the work done here is in many cases original both in conception and execution. The physical conditions on the Pacific Coast differ so widely from those of other parts of this country that the engineer must adopt special methods to meet these conditions, and the methods adopted and the conditions to be met are matters of great interest to engineers the world over. Our engineers should record their experiences in dealing with them in the transactions of the Society that represents them to the world. This, of course, requires meetings like the present to give the opportunity to the members to present either their written or spoken experiences and printed transactions to carry them to the outside world, but to make this machinery effective much is needed on the part of the members. There must be the habit of careful observation and the ability to record observations in words that will enable another, who has not had the opportunity to observe, to understand. There must also be a willingness to sacrifice present ease and comfort in order to secure

recognition from fellow-workers in the same profession. It often requires the sacrifice of many comforts and enjoyments to sit down of an evening and record the experiences of the day that are oftentimes very disheartening, but which might save a like experience to some other engineer in the solution of a similar problem. It is so much easier to forget those troubles than to record them, but the engineer, like others who aspire to high positions, must come to his kingdom through much tribulation, and it is only through having a record of the battle that the victor is known. There must also be a spirit of unselfishness on the part of those in control of large engineering undertakings. They should remove all obstacles which would prevent their engineer from giving to the profession the benefit of the experience he has acquired in their service. Obstacles of this character are to a large extent responsible for the meager character of the engineering records of work done on the Pacific Coast. This policy is not only selfish but in the long run most decidedly unprofitable. I think, however, that we are improving in this respect, and will continue to gather wisdom on this point as we grow older.

The engineering work now being carried out on this coast is beginning to be of a different character from that which used to characterize the work of the engineer. The permanent is taking the place of the temporary, which means that men of known ability will be in charge of such work, plans will be more carefully considered and by more experienced men than hitherto, and this is another reason why engineers should make their work known through such Societies as this, for what a man has done successfully will become more and more the measure of what he can do. We have many able engineers in the various branches of the profession here, some of them well known beyond the boundaries of the Pacific Coast, and there are many just as able who are not known. These men have been hiding their talents under a bushel. They may think that it is modesty on their part, but in most cases it is indifference, which is quite another thing.

We have each been so absorbed in our own little engineering problems that we have failed to notice the growth of things about us. The opportunities for engineers to take their part in the development of the varied resources of the Pacific Coast have been steadily increasing, until now the field is a broad and attractive one, inviting us to take a hasty glance at what it offers to the men now preparing themselves to stamp their characters on some part of it.

In railroad engineering, always a large factor in the development of a country, we have already done much, but what has been

done is only the beginning of what is ultimately to be a marvelous system of transportation, affording unlimited opportunity for engineering skill. The railroad engineers who planned the steel highways that have opened the beauties and riches of the Pacific Coast to mankind have left many traces of their skill amid the high Sierras that form our eastern bulwark, but these engineers have left little or no trace of their work in the annals of engineering. It is very unfortunate that this is so, for the past record of railroad engineering on the Pacific Coast, had it been preserved in the records of a Society like this, would have been a bright chapter in engineering experience. The temporary ways of the past are fast becoming the permanent ways of the future, as regards our railroads, and grand opportunities are to be afforded to the railroad engineers of the future. The mechanical engineer as well as the civil engineer will have his opportunity in the railroad development. Radical changes in the motive power are beginning to be felt as a necessity, and we seem to be on the verge of some great surprise in this field of engineering, whether this is to come from improvements in the present type of prime movers at the heads of trains, or through discarding the locomotive altogether and adopting some system of power stations where mountain torrents will be converted into electric energy to be applied by some new system to the railroad cars, cannot perhaps now be predicted, but I feel sure that some such change is in the near future. The younger member of the railroad family, the trolley car, though quite young, has had a remarkable growth, and who can tell what its future will be and what a field for engineering there is in its development. All branches of engineering are enlisted in the work of advancing this system of transportation—the civil engineer in finding a way and making it permanent, the mechanical engineer in devising and putting in operation the engines and generators (which are fast getting to be works of great magnitude), and the electrical engineer in designing generators to convert great units of power into electric energy and means for transmitting it to transforming houses and thence to the car lines. It might almost be said that a new science has been created to satisfy the demands of the electric railroad. Here, the engineer has a field to work in that is almost virgin soil, and that field on the Pacific Coast is even now a wide one and its possibilities very great.

The development of water power on the Pacific Coast, which has already made creditable progress, is, I believe, destined to be one of the leading factors in the future prosperity of this State. Some notable examples of this class of engineering have already been successfully carried out, and the technical history of these undertakings

should now be in our Transactions if the able engineers in charge of them would have given the time necessary to preserve the record of their own work, of which, I am sure, they need not be ashamed. Perhaps no section of the world's surface is better adapted to the utilization of water power than the Pacific Coast, with a background of mountains facing fertile valleys for more than a thousand miles in length and with streams rushing down the mountain sides at convenient intervals, having water heads as great as the mechanical engineer cares to deal with. If what has already been done in this branch of engineering on the Pacific Coast had been suitably recorded and illustrated in our Transactions, it would have enriched our records and made them a fit legacy for those who are to complete the work of conserving and converting into useful work the melted snows of our mountains on their way down to the valleys, where having lost their head by the way they may finally give their body to enrich the soil. There is no limit to the engineering possibilities in this department of applied science, and, in order that the Technical Society may have its share in the grand result, its members must bring their schemes and experience gained in working them out before their fellow-members, thereby insuring recognition both for the work and the worker.

A kindred subject to the utilization of our water power resources is that of the direct application of steam to turbine wheels, which is now threatening the long-established supremacy of the reciprocating engine. Neglecting the claims of Hero of Alexandria, dating back some 2000 years, we may say that the practical steam turbine is but a thing of yesterday, as it has not reached its majority yet as against the 200 years of the steam engine. It would be useless to conjecture what the prime mover may be 100 years from now, but there is little doubt that in the near future the infant steam turbine will, for many purposes, be a strong competitor with the maturely aged reciprocating engine. The steam turbine has already demonstrated the possibility of a working economy equal to the most advanced type of reciprocating engine, and great progress has been made in overcoming the mechanical difficulties of the problem. Hitherto we have been more interested in producing water wheels than steam wheels, but if the Pacific Coast should in the future do as much for steam wheels as it has done for water wheels, we will have an honorable share in the perfecting of this new steam motor.

In the developing of our natural harbor facilities, and creating artificial harbors where Nature has neglected to provide such facilities for commerce, there is a great and growing field for the civil engineer on the Pacific Coast. The day has about passed when tem-

porary harbor work will be accepted. Permanent works will be demanded and engineers competent to meet the demand will be required. The western edge of the United States is destined to play an important part in the commercial future of the Pacific Ocean, and present indications point to that future being big with possibilities which to-morrow may be probabilities and the next day actualities. Technical men will bring about this wonderful development, which will come more rapidly than even the most sanguine of us expect.

This country has now committed itself to building a canal through the attenuated waist of the continent, and one of the members of this Society has been given a place on the Commission to carry out this great work. We feel proud of this honor, and I have no doubt that when this great undertaking is complete the wisdom of this choice will be manifest. In the meantime this appointment ought to encourage every engineer on this coast and lead to a desire on the part of everyone in the profession to let his work be known and discussed, as thereby he will bring about a recognition of himself.

I trust that the success of this gathering of technical men will encourage the Society in this new venture, and that the members will not only look forward to the enjoyment of such meetings, but will prepare for and bring to them the very best things they have gathered in their professional work and experience. Professional men can benefit themselves and their professional brethren greatly by bringing their work, and especially their difficulties, before each other for discussion. No one can impart to another his experience, but the telling of it may suggest a field where we might work out some new experience for ourselves.

Experience is the principal stock in trade of the engineer, and Pacific Coast experience differs from all other engineering experience. The world should therefore know that quite a fund of it has been collected by the professional men here, and while it is an individual asset of him who has gained it, I would not like to have you think that I had little faith in any other teaching than that of one's own experience. You must not let any such impression be made on your minds by anything I may say on engineering experience, for anything I may say had better not be said at all than that it should have such an effect. I had not in my younger days the opportunity to learn all the recorded experience of the best thinkers in my profession, as many of you have had, and I sometimes think that many a dark passage in my book of experience had been spared me if I had had such opportunities. You will understand, therefore,

that when I speak of engineering experience I do not mean to say that that is the sum of all that an engineer ought to know, for the lessons to be learned in the school of experience will come easier and sooner to the man who builds his experience on a broad foundation extending deep into the accumulated experience of the profession.

I cannot tell you anything, to-night, of my own experience as an engineer, for the very good reason that there seems to be some impediment between one mind and another that prevents one man imparting his experience to another. We can speak about experience and the necessity of having it, but we cannot impart it to each other. There is plenty of it all around us, but each must gather it for himself, and does not always get the kind he thought was coming to him.

What, then, is the thing or quality of mind that men call experience? It is, I think, the formative or molding effect upon the mind of all the thoughts that pass through it from within, and all the impressions received by it from without, relative to the work with which our lives are identified; and the mind becomes rich in experience in proportion to the concentration of thought within and the strength of the impressions from without in regard to the matters we desire to become experienced in.

Memory, I think, must be a powerful mental factor in experience; in fact, the man of experience is such by virtue of the store of impressions he has gathered and arranged in his mental storehouse in such order as to be readily produced at the moment when their evidence is required to decide his course of action in regard to the subject to which these impressions relate. When a plan or design for any engineering work is presented to an experienced engineer for his opinion as to its merits or practicability from an engineering or commercial standpoint, a series of pictures at once present themselves to his mind. Mental photographs, as it were, of similar works, or works of the same character that he has been connected with in the past—where they succeeded and where they failed—are clearly pictured to his mental vision, so that he will be able to readily compare these pictures in his mind with the proposed plans before him; and as the pictures of failure or success most nearly coincide with the plans before him, so will his opinion be. This is experience, and it is the quality in an engineer that commands the highest price in the engineering market.

The brilliant young man who has been nursed at the public breast of recorded experimental data, but without any experience of his own, is often skeptical in regard to the experience of older men in

the profession. He considers engineering as an exact science, and that all problems in engineering are capable of demonstration, and that if the past work of any engineer had been carefully figured out in all its details by the methods he has learned to understand so thoroughly, these mental impressions I have referred to, so far as they represent finished results, would simply all be brilliant pictures of success.

I have no doubt about engineering being an exact science, but the engineer has not yet discovered the exact way to apply the science of engineering to the ever-shifting conditions under which he must do his work. His most careful and exactly figured-out designs sometimes surprise him by utter failure, while another design, under quite as difficult conditions, that he has given less time and thought to, may equally surprise him by its complete success. The static laws and dynamic forces in his most carefully planned machines sometimes get into most fatal misunderstandings with each other, and he stands puzzled amid the mechanical wreck without any satisfactory reason furnished by the result to show why the thing that figured out so exactly right should be so hopelessly wrong. But if he is a wise man the impression will not be lost, and will always be ready whenever his opinion is required on a class of mechanism of which this picture is a type.

Did you ever observe the difference in appearance between a piece of mechanism designed on scientific principles, with every part figured out to stand the strain that theoretically should come upon it, every journal having just the proper amount of surface for the load, and another piece of mechanism for the same duty, but developed by experience with the working of many predecessors? No scientific reasons could be given for the forms that certain parts had developed into, except that they would not work satisfactorily in any other form. It is not safe for any engineer to look upon general practice as the result of lack of knowledge. In all our designs we are on dangerous ground when we neglect the teaching of general experience. I have said something about engineering being an exact science; this is true only in part. The laws that govern bodies in motion and at rest, the expansion of gases, the conservation of heat and energy, are all exact in their operation, and the same conditions will always produce the same results. But the engineer has to apply these laws and forces through materials, used in the construction of the work he designs, that are varying in their qualities of strength and endurance, and what will behave satisfactorily at one time may utterly fail at another time, when to all appearances the conditions are the same.

Two metal surfaces may work on each other as a journal and bearing with perfect results at one time, leading you to believe that you had reached the desired end of your search for a satisfactory bearing metal; yet when you duplicate it under apparently the same conditions, the result is a disappointment, showing that your first experience, though successful, was very near a failure, only you did not know it. This is why an experienced engineer will sometimes not repeat work that those not in his confidence may have considered a great success.

This illustrates what I mean by saying that no man can impart his experience to another, as it is acquired for his own use only. If we were to be guided by another's experience, progress would be at an end in certain directions. Men have found by experience that certain things could not be done, because they have tried and failed to do them, and this experience was enough for them. They may also have given the world the benefit of their experience, telling others that such things could not be accomplished, because they had tried and failed; yet other men searching for an experience for themselves will try and do those very things that could not be done, and do them successfully, and thus gather an experience that contradicts that of the other. And this process goes on continually. What my experience tells me will fail, another's experience tells him will succeed, and yet my own experience must guide me, and not that of another.

Experience is a thing of slow growth, for often the first impressions produced by our work have to be modified as certain tendencies on the part of the work develop. This is especially true of moving mechanism. An engine or machine may make a fine start, engineering experts may give good reports in regard to it, and the designer may feel justly proud of the result of his labor; but by and by certain tendencies begin to manifest themselves; workmen are employed nearly every night to keep it in condition to run in working hours, but the fatal tendencies keep developing, until the machine is broken in constitution and is no longer fit for duty and must be abandoned. This is the end of many a fair start; and alas! how many of the model engines and machines that get conspicuous illustration and description in engineering publications come to just such an end, while other machines that required careful nursing at the start have developed constitutional strength that enabled them to serve their day and generation with credit.

I have found it very instructive to go back 10 or 20 years and study the designs for engines and other machinery that figured in the engineering papers and magazines, and that were advertised at

the time as the result of the best experience of the people who made them, and trace them on through succeeding years, noting how many of those receiving the highest commendations drop out of existence altogether, experience having shown them to be constitutionally defective; while others having sound constitutions as a foundation for development appear again and again, modified to suit varied conditions, but still showing through all changes the good stock from which they sprung.

Our own experience must be the result of wider observation than the limited horizon of our own work. We must make careful studies of other men's work. We cannot get their experience, but we can test our observations of what others do by an experience of what we have done in the same line ourselves, and thus enrich and broaden our ideas of the possibilities within the branch of engineering in which we have chosen to labor.

It should be the aim of every engineer to make himself an ever-growing power in his profession. This he can only do by continually increasing his resources, by carefully hoarding every item of experience that comes to him, either through failures or successes; both must often come to the man who leads a busy life in our progressive profession.

It is not at all necessary to parade our mistakes, even before the Technical Society. These lessons are for ourselves only; others may have to pay for them, but the profit should be ours. It is the duty of every engineer to hide his mistakes as far as possible; he should be the first to discover them and the most qualified to correct them, and, above all, he should be the last to forget them, for the memory of them is his experience.

Individual experience is a growth, beginning with the first child effort to make something and the impression that product made on the young mind that produced it, showing the direction in which a better thing might be made, the thing produced giving the mental stimulus for the next and higher production; and thus should our experience grow richer and stronger as our lifework advances. Careful observation of the things we have made, performing the functions for which we made them, enables us to make better things in the future, having more varied functions. It is the man who is most critical of his own work that becomes the man of rich experience. We must get on very intimate terms with our own work if it is to be the mine from which we are to dig the experience that will make us a power in our profession.

Some young men think when they have taken a course in engineering at a university that that should give them a place in the

profession, but that is not so. The fact that they have learned something of engineering at a university places them under great obligations to the profession, for they have been receiving out of the accumulated store, gathered by the best men of the past; and it is not what one gets, but what one gives to the profession that will make him a place among its honest members; nor can he borrow what he gives—it must be his own honest work. Therefore, I would say to the young men who are trying to find an honorable place among engineers: Don't go around seeking for friends to get you a place, but make up your minds what place you would like, and don't be afraid to make it high enough. Then to work! no matter how distant that work may be from the place you aspire to, if it points in that direction. Stick to it; don't waste time consulting with friends about your prospects and seeking introductions to people who will help you to the place you desire to reach, but make a close friend of your work—your best advice and surest advancement will come from it. Study the results of your work while others are seeking influence; put these results in the clearest language you can command and bring it to the Technical Society. Let no tendency in your line of work escape you. Feed your experience by close observation, and some day someone will want something done for which your experience is absolutely indispensable. You will need no one to introduce you to that man; he will search for you and be very glad when he finds you; and your place among engineers will be the very place you selected and worked to prepare yourself for, and which will be yours by right, and not by influence.

My dear friends, I doubt whether I have succeeded in giving you a satisfactory inaugural address. It is difficult to convey in words what I know engineering experience to be. I will be satisfied if I have succeeded in impressing, especially, our younger members, with the importance of acquiring experience as opportunity enables you to do so; considering your work, not the fruit of your life, but the planting, from which you and others are to gather in time the rich fruit of experience. For I promise you that he who thus utilizes all the work that goes through his hands will not fail to find the place he desires among the engineers of his time.

THE LAYING OF THE COMMERCIAL PACIFIC CABLE.

By Frank P. Medina, Member of the Technical Society of the Pacific Coast.

[Read before the Spring Meeting of the Society, May 26, 1904.]

The design, construction, laying and maintenance of a long submarine telegraph cable involve scientific processes of considerable exactness and complexity and engineering work of much skill. The problems of design include some of a mechanical nature, which, in the present state of our knowledge, are usually simple; and some of an electrical character, which are rather more abstruse and difficult. The cable must have sufficient tensile strength to permit it to be safely laid in very deep water, and to be picked up should it become necessary; and, since its cost is very great, it must have a correspondingly long life. There must be a central conductor, consisting of a single group of copper wires, usually composed of 7 separate strands (11 in the Pacific cable), and these are covered by a coating of insulating material, for which nothing has been found so well adapted as gutta-percha. The conductor must be of sufficient conductivity and the insulator of sufficient resistance, and have just the right amount of inductive capacity to enable the specified number of words per minute to be transmitted. These considerations suggest some of the problems of design. The laying of the cable calls for a survey of the projected route and a detailed knowledge of the soundings thereon, a specially constructed ship having adapted tanks for storing the cable, and special apparatus on board ship for paying it out and testing its continuity and resistance during the laying. Its maintenance calls for means of locating faults and of grappling and raising the cable to the repair ship, and apparatus for uniting conductor, insulator and armor. Its operation demands very sensitive recording instruments, since only a very small proportion of the total energy used in signaling is available for useful work.

It is the object of this paper to touch on some of the points of design and construction, laying and maintenance of submarine cables, with special reference to the Commercial Pacific Cable Company's cable between San Francisco and Manila, the laying of which was completed on the 4th day of July, 1903.

The specification for cables usually prescribes that they shall carry a given number of words per minute, by the hand signaling method, which number in the case of the Commercial Pacific Cabie Company's cable was 28 words. The speed of signaling in sub-

marine cables is inversely proportional to the resistance of the conductor and the electrostatic capacity of the insulator. The product of the capacity K into the resistance R, the former measured in microfarads and the latter in ohms, is a measure of the time it takes an impulse wave to rise and fall between its lowest and highest values, and the K R is a constant for each cable. For cables of given conductivity and capacity per unit of length, the time of such rise and fall of impulse waves varies as the square of the length of the cable; for both K and R increase directly as the length increases.

Existing cables supply the data for applying the K R law to a proposed new cable. The capacity per knot in microfarads into the copper resistance in ohms of the datum cable furnishes a coefficient which, multiplied into the ratio of words per minute of the datum cable, to the words per minute required in the new cable, and into the square of the ratio of the length of the datum cable to the length of the new cable, gives the required K R of the new cable.

From the K R thus derived the size of the copper conductor and the thickness of the insulation are calculated. A gutta-percha resistance between 3000 to 7000 megohms per knot after 1 minute's electrification is chosen, for the reason that a higher insulation retards the speed of working, because too much of the discharge of the cable has to leave at the extreme ends instead of leaking through, and because a lower insulation affects the stability of the gutta-percha. The calculations must be made with reference to the fact that the insulation resistance of gutta-percha increases with pressure due to the depth of the water in which it lies and with fall of temperature. The variation due to pressure has been determined at 61¼ per cent. per 1000 fathoms depth. The variation due to temperature, as observed by experiments on the Persian Gulf cable of 1863 and the French Atlantic cable of 1869, showed that the change in resistance between 75° F., at which the factory tests were made, and 53° F., the temperature of the experimental tests, was 3.912 to 5.042 times as great.

The temperature of the sea bottom between San Francisco and Honolulu, like that of the North Atlantic, averages about 35° F., and the mean depth is about 2500 fathoms, with a maximum of 3073; between Honolulu and Midway Island the mean depth is 2000, with a maximum of 3026; between Midway and Guam the mean depth is 2600, with a maximum of 4900, and with sudden and great fluctuations; and from Guam to Luzon the mean depth is 2200, the maximum being 3400.

Such was the problem that had to be worked out by the India-

Rubber and Gutta-Percha Telegraph Works, of London, and by the Telegraph Construction and Maintenance Company, to whom the contracts for constructing and laying the cable were awarded. The speed was to be 28 words or 140 letters per minute.

In its length of 8300 nautical miles, the copper conductor weighed 3,600,000 pounds, the gutta-percha insulation 2,310,000 pounds. The conductor and insulator form the core, outside of which is a cushion of jute yarn weighing 2,010,000 pounds, and between this cushion and the core is a brass sheathing in the form of a tape, to protect the gutta-percha from the teredo and other marine borers. This sheathing weighs 52,000 pounds. Outside the jute cushion an armor of iron and steel wires gives it tensile strength and resists mechanical injury, and this armor weighs 19,000,000 pounds. The armor is covered with preservative tapes, of which there are 306,000,000 yards, the compounds on which weigh 4,220,000 pounds. The diameter of the copper conductor is 0.1801 and the thickness of the insulation is 0.2417. The outside diameter of the deep-sea cable is 0.936. But the shore ends of cables are always much larger, being much more heavily armored, to protect the cable from dragging anchors and resist the constant wearing action of the tides. The shore end of the Commercial Pacific cable is 2.4 inches in diameter.

The reason for giving the contract for the construction of the Pacific cable to a foreign company was the lack of sufficiently high development of the art of submarine cable manufacture in this country. The risks of failure were so great, and the penalty for failure so serious, that nothing short of the skill and experience which English manufacturers had gained during years of practice was deemed available.

The armor is composed of steel and homogeneous iron wires, the elongation being about the same in each; that is, about 5 per cent. The total weight of deep-sea cables is about $1\frac{1}{2}$ to 2 tons per knot, but shore ends weigh 15 to 20 tons.

When the San Francisco-Honolulu end of the cable was completed in the factory, it was run on board the ship "Silvertown" and coiled in tanks in her hold. This coiling is carefully done with reference to keeping the ship in trim, each tank being filled to $\frac{1}{2}$ to $\frac{2}{3}$ its capacity. Any want of trim is corrected by filling the necessary water ballast tanks. The coiling takes place from the outside circle of the tank inward to a central conical core, and when the innermost turn of 1 flake is laid next this core the cable is taken back straight across the turns and coiling from the outside recommences.

You will probably recall the arrival and departure of the

"Silvertown" on her expedition with the San Francisco-Honolulu section on board. She is 350 feet long, 55 feet broad, 34 feet 6 inches deep, and fitted with engines of 1800 horse power, steaming at a speed of $10\frac{1}{2}$ knots, with a coal consumption of 30 tons per day. She carries 3 tanks, 32 feet in depth, the largest being 53 feet in diameter.

The landing of shore ends is usually accomplished by loading the cable on lighters. For the Pacific cable, the landing of the San Francisco end was done by unloading several miles on a steam schooner, the great draught of the "Silvertown" compelling her to lay too far out to permit of dragging the cable to the beach directly, even when supported by balloon buoys. But the schooner was enabled to come inside the San Francisco sand bar, which skirts the Cliff House beach, and the shore end was duly landed and carried to the cable house, just back of the Life-Saving Station, in a trench running therefrom to low-water mark.

The schooner proceeded to pay out the shore end as she steamed to the "Silvertown," when the remainder of the cable was coiled on board, and being spliced to the coils in the tanks was carried by the "Silvertown" on her way.

The shore end is spliced to a piece of cable 2 miles in length, smaller than the shore end, but larger than the deep-sea cables; for there are usually 3 types of cable, as in the present case—a shore end, an intermediate and a deep-sea type. And when finally this intermediate end was spliced to the deep-sea end the voyage began in earnest.

Electrical communication is maintained between the ship and cable house at all times during the journey. Both on shipboard and on shore, the spot of light on the galvanometer scale is anxiously and continuously watched, to note the appearance of any sign of flaw as the cable sinks overboard. The electrical engineers watch for a momentary fluctuation of the light spot at intervals of five minutes, due to impulses transmitted from the far end, as this assures them of the continuity of the conductor; while the relatively quiet location of the light spot at zero at all other times shows the perfection of the insulator.

The cable is passed through a bell-mouth fastened across the hatch over the tank, and thence to the paying-out machinery. From the tank over leading pulleys it goes to the friction table, which is a device for applying a retarding strain instantly if needed. From the friction table it goes to the paying-out drum, round which 3 or 4 turns are taken, and thence to a dynamometer and over a stern sheave to the water.

The drum is provided with brake wheels, the friction on which can be adjusted by weights on the ends of levers in accordance with the conditions of depth, type of cable and speed of ship. A steam engine is also fitted, capable of being put in gear with the drum when required, as to haul cable inboard when a kink or fault has been paid out, or to haul up cable from the tank at starting.

Two brake wheels are mounted on the drum shaft, and have brake straps of stout iron carrying hard-wood blocks which bear truly on the surface of the wheels. Levers pivoted near the shaft operate the brakes. Each of the levers carries a vertical rod working in guides, and on these rods weights are placed in accordance with the power required. Means for readily loosening the brakes are provided, so that they can be thrown off whenever the dynamometer indicates an extraordinarily heavy, sudden strain.

The aim is to lay the cable along the bottom of the ocean without strain and without unnecessary slack. In 2900 fathoms, with the ship steaming at 8 knots an hour, 25 miles of cable are in suspension in the water. Two and one-half hours are occupied in such case by any particular point in the cable to sink to the bottom.

It is aimed to lay the cable along a route free from sudden elevations and depressions, and especially to avoid the craters of submarine extinct volcanoes. The soundings taken by the survey ships are usually of insufficient detail to guard against this, therefore a system of continuous soundings is kept up aboard the cable-laying ship. One of the instruments used in this service is the James submarine sentry, a kite-like device of wood, so attached to the sounding line that the speed of the vessel, resistance and line of impact of the water keep it constantly at a selected depth, until it strikes an obstruction, as a submarine mountain top, whereupon its kite-like connection with the sounding line is tripped, and it floats to the surface, a dead piece of wood on the end of a wire.

The chemical constitution of the ocean bed is also a matter that needs to be known, and is important as affecting the stability of the armor. Tubes are attached to the sounding line, and being equipped with suitable valves, bring up specimens of the bottom when the line is hauled in.

The San Francisco-Honolulu section of the Pacific cable was laid in 10 days, without troubles of note, until near the time for landing the shore end at Honolulu. When 35 miles off the Hawaiian coast a heavy storm appeared, which threatened to prevent the landing on Christmas day, 1902, the date for which the event had been scheduled; but, notwithstanding this untoward event, the landing was made nearly on time and the cable showed no fault.

If a fault had developed meantime, it would have been the first act of the engineers to make location tests ascertaining its position. These tests are made with galvanometers and accurately adjusted resistance coils, and, where the fault is a defect in the insulation, consists in discovering the resistance of the copper conductor between the end and the fault. The resistance per knot of the cable at a given temperature is already known, the mean temperature of the bottom in which the cable rests is also known, and therefore the galvanometers' indications are readily reducible to distances in knots, and the position of the faulty point ascertained by reference to a chart on which the whole cable has been plotted. But in making this location test, the fault itself forms part of the circuit; and as cable faults have a habit of varying their resistance between very wide limits, it is a matter of great nicety to tell just what is the copper resistance between the end and the fault. Various modes of doing it are used on single conductor cables; but where 2 conductors or 2 cables are available, so that a metallic loop can be formed, the fault being in one of the conductors only, accurate location tests are readily made, and variations of resistance in the fault are no longer a source of inaccuracy. With single conductors to deal with many tests are made from both shore ends, all the results being compared, those from each end being checked with those from the other, until an agreement is obtained, which shows the proximate position of the trouble.

Suppose a fault had developed some hundreds of miles back from Honolulu. The "Silvertown" would have had to return to the spot indicated by the engineer's tests, and by grappling would have had to bring the cable to the surface. In calculating the proper tensile strength to be given a cable, in order that it may stand this picking-up strain, it is usual to allow a factor of safety of 3 or 4.

Arriving at the indicated spot, observations for position are taken and a mark buoy anchored at the place. Proceeding a mile at right angles to the supposed direction of the cable, the ship, with dragging grapnel, sails back and forth across the line, until the cable is hooked. It is thereupon hauled aboard and cut, and the direction and distance of the fault from the ship determined by further tests. This matter being settled, the end of the perfect cabie is buoyed and the end of the faulty cable carried through the picking-up gear to the tank, where it is kept in constant connection with the testing room.

The picking-up gear consists of a bow sheave, over which the cable is led to the steam-driven drum of the winding apparatus, whence it leads through guide sheaves to the bell-mouth over the

tank. There it is coiled about by attendants, as when first taken aboard ship.

The testing galvanometer is meantime being carefully watched for any change in deflections, as such change indicates a mechanical disturbance of the fault, and when the fault is finally brought on board the cable is once more cut, this time at a point beyond the fault, and the now perfect cable in the ocean is spliced to the piece in the tank.

The copper conductors are laid together by a scarf joint, soldered and wrapped with fine wire. The gutta-percha is then warmed at one side of this joint and drawn down over it. The other end of the gutta-percha covering is warmed and drawn down over the first layer, so as to inclose the copper completely. This makes a very thin covering over the conductor. At the middle of the joint a roll of gutta-percha tape is twined about the joint, and being warmed is spread to the right and left until it covers the whole joint. More perfect adhesion is effected by the use of a cement of gutta-percha and tar, called Chatterton's compound; and when the splice is completed it shows but very little larger than the other parts of the core.

The core being joined, the remainder of the cable wrappings and the armor are connected together, the cable thrown overboard and the ship sails back to the buoyed end, where the final splices are made.

This is what would have happened if a fault had developed during the "Silvertown's" voyage; but as it turned out there was no such mishap, and she made an average of 200 miles a day for the journey.

The contract for the sections of the cable between Honolulu and the Philippines had meantime been awarded to the Telegraph Construction and Maintenance Company. The cable ships "Colonia" and "Anglia" left London on the 9th and 10th of April, 1903, with the cable on board. The "Colonia" is the largest cable ship afloat, having a dead weight capacity of nearly 11,000 tons, with a capacity of 4000 knots of cable in her 4 tanks. The "Great Eastern" had not more than half this capacity. The dimensions of the "Anglia" are somewhat smaller.

The "Anglia" started from Manila on May 24th, arriving at Guam on June 2d. The "Colonia" had reached Guam on May 27th, and the engineering and electrical staffs from the "Anglia" were transferred to the larger ship, which proceeded on its journey to Midway, arriving on June 19th. At Midway, the "Anglia" joined

her, and reshipping the engineers, laid the remaining section of the cable to Honolulu, completing the work on July 4, 1903.

The maintenance of so many thousands of miles of submarine cable is matter of much expense and consideration. The shore ends are subject to injury from dragging anchors, and the armor is likely to be eroded by the action of the tides. Chemical action from substances contained in the sea bottom, the attacks of submarine borers, effects of submarine volcanic action and even the acts of the larger aquatic animals are sources of interruption which manifest themselves from time to time.

Weekly observations of the electrical condition of the conductor and insulator are taken, and accurate records kept thereof, to be used as data in locating faults.

Besides the dangers from submarine activities cited above, there is always a liability to injury from excessive current or electromotive force from the land ends, caused by lightning or stray power currents. Indirect working of the cable through condensers and careful fusing diminish this danger.

The great cost of long cables makes it very desirable to bring their working capacity up to the highest notch. As above stated, it is not practicable to work more than 1 conductor in cables over 500 miles in length, on account of their mutual interference with signaling; but it has become possible to practically double the carrying capacity of single conductors by working them on the duplex system, whereby 2 messages may be transmitted in opposite directions at the same time. The duplexing of cables of considerable length is a matter of great delicacy—much more delicate and difficult than duplexing land lines. The attempt to quadruplex long cables has been made, but without success.

As to the future of submarine telegraphy, now that we have a new system of communication through the atmosphere which does not use wires at all, I have only to say that the projectors of the Commercial Pacific cable had witnessed the best performances of the wave telegraphs before they began to lay their cable, and that these performances failed to stop them.

SIMPLE STEAM TURBINE ENGINES.

By John Richards, Member of the Technical Society of the Pacific Coast.

[Read before the Spring Meeting of the Society, May 27, 1904.*]

I should perhaps apologize for presenting before the Society a paper of so elementary a nature as the one that follows; but it may be assumed that such papers are directed to two objects—the advancement of technical knowledge among the members and the furnishing of popular information on technical subjects. The present paper belongs mainly in the second category. It is devoted to a subject so new at this time, in a popular way at least, that its elementary character will be an advantage, especially as the scientific phase of the subject has had copious treatment at the hands of others.

It is a strange fact that the "evolution" of steam turbines is following a course quite the opposite of that of piston engines. In the latter, the constructive part was developed and in a great measure completed before the thermal or thermodynamic features were investigated and explained; and, as a matter of fact, ignoring the modern demands of increased speed and pressure, the constructive feature of such machines has not greatly advanced in recent times.

Some of Watt's steam engines remained in constant use for a century, and many old engines made in this country had a record of 50 years and more; but, as remarked, the thermal or thermodynamic features that pertain to the art have only in recent times become understood and applied. Thirty years past will include what may be called the scientific evolution of piston or pressure steam engines, and, with some exceptions, will include the development of their proportions and their arrangement into types.

In steam turbines, the scientific part has preceded the constructive one; in fact, was complete in essential points when their practical construction and use began. This was, of course, because all steam and heat engines are governed by the same general laws, with the difference that turbine or impulsive engines deal with the flow and gravity of steam instead of its pressure, and hence are more complicated in several respects, but, as before remarked, they follow certain ascertained laws which govern heat engines in general.

The problem of constructing turbine engines has, as may be claimed, only begun. Even the types are not yet determined, and

* Manuscript received June 30, 1904.—Secretary, Ass'n of Eng. Socs.

no doubt many years will elapse before this branch can reach a successful evolution and constant types appear. Design and methods of construction must arise out of use and experience, and must be proved by the inexorable tests of efficiency, endurance, adaptation, economy and cost.

A principal fact, relating to turbine engines now in use, is that while this term is applied to all kinds of steam wheels driven by impact, reaction, or pressure of steam, there are two types that are quite distinct as articles of manufacture. One of these types I will call "single" acting, the other "stage" acting. These types are best known in common speech by the names of inventors who have in recent times been most prominent in their development; the single acting as the De Laval or Riedler type, the stage or double acting as the Parsons type. Another type, that will have some notice hereafter, is the reaction type, not commercially made at this time, but a "parent" of the whole, as will appear.

The two first named types of engines are also designated as impulse and pressure machines, but these terms do not very clearly define just what is meant; they are, however, as nearly descriptive as any that can be selected for the purpose. The action to be described in these cases will be better understood by saying that one operates by "push" and the other by "blows." One is free running or open, the other inclosed to maintain pressure.

Of steam turbines, those of the stage or Parsons type are at this time the most numerous and the best known, and they have engrossed the thought and skill of many able engineers. They correspond in many respects to inclosed or pressure water turbines of the Jonval, Fourneyron and centripetal types, which act mainly by "push" or pressure, but not by sustained pressure in the same way as in the action of pistons.

The stage or successive action of the steam in this type of engines has for its main object the reduction of speed and rate of revolution, thereby adapting the machines for coupling directly to pumps, dynamos, marine screws and so on. It also avoids the enormous centrifugal strain set up in single-action machines.

Turbines of the single-action or impulsive type are open and without maintained pressure, as in the tangential, Girard and other unfilled water wheels. Consequently they have no running joints to maintain against steam pressure.

Steam and water turbines being analogous in many of their features, and the latter being much better understood, especially on this coast, where water turbines of all kinds are employed, a comparison will aid in the present explanation.

The main distinction between steam and water turbines arises out of the different natures of the two fluids. One is elastic and light, the other inelastic and heavy. In the case of water the velocity of efflux is low and in proportion to its density, reaching a velocity of about 80 feet per second under a head of 100 feet, or a pressure of 43 pounds per square inch; but in steam the velocity is immensely greater. The velocity, in feet per second, of efflux from nozzles equals 60 times temperature in degrees Fahrenheit plus 460. This gives a velocity of 1680 feet per second for steam at a pressure of 100 pounds per inch; but this is much less than is now assigned for actual efflux from nozzles on which the speed of turbines must be computed. The practical velocity of turbine wheels is computed on a flow of 3000 to 4000 feet per second, and for the vanes from 1200 to 1500 feet per second, or 75,000 to 100,000 feet per minute.

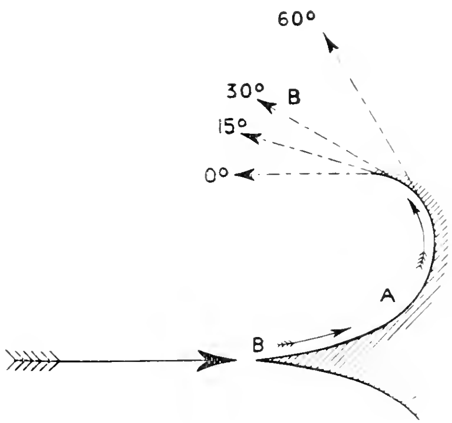


Fig. 1.

This is more than 12 times the rate of the fastest railway trains, and, as a physical fact, almost evades the power of conception.

Otherwise than as to the great difference in their velocity, steam and water turbines follow like laws; the spouting energy, as it is called, being theoretically equal to the gravity; or, in other words, the "blow" is equal to the "push," provided the kinetic energy of the impact or blow can be equally utilized.

The action of all unconfined liquids is expressed in an old rule (it may even be called a gospel) of fluid motors: The fluid must "enter without shock and leave without velocity." This rule, applied to any motor driven by the impulsive energy of a fluid, will determine the correctness of the machine's operation, or, as it is called, its efficiency, meaning the useful effect produced in proportion to the weight and velocity of the fluid consumed.

To further explain this action of fluids, if a stream is directed against a fixed flat surface, only a portion of the energy is imparted to the surface, about one-half in fact. The entry is a shock, and the fluid is scattered in a lateral direction with violence and leaves with velocity. If the same stream of fluid is directed tangentially into a curved vane or bucket, as in Fig. 1, and if its course is gradually reversed, it will leave with velocity, and that much of its energy will be lost; but if the bucket or vane A is set in motion with the fluid at one-half its velocity, then, by the component of these motions, the fluid will be brought to a state of rest, and will leave without velocity, the buckets receiving the total energy less fluid friction and some loss due to the divergence of the lines B. This is the manner of operating in all fluid motors of the impulse type or of single action.

The tangential entrance of the jet or stream and the resultant or discharge angle are very important features in practice, and will

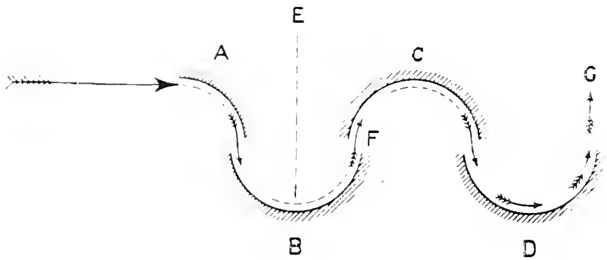


Fig. 2.

be again considered at some length, not in respect to economy alone, but as materially modifying construction in several ways.

Reverting now to the filled or pressure class of turbines for water or steam, these operate in a different manner, by what is commonly called pressure, but not pressure within the usual meaning of this term. "Obstructed flow" comes nearer describing the operation.

The course of the fluid through the machines is made so tortuous or difficult, by means of reversing or baffling curves or vanes, that the gravity or pressure of the fluid acts like a static force.

Fig. 2 illustrates, in an imperfect way, this action, the large arrow, in this as in other diagrams, being employed to show the line of impingement or course of the fluid.

If all the vanes or buckets, A, B and C, were fixed, it is clear that the water would be discharged at G with reduced velocity, even if it were confined; but if the vanes B are set in revolution in the

plane at E at half the velocity of the water, it will be left at F in a state of rest or without velocity. If the vanes B are set in revolution at one-fourth the velocity of the water, there will be a residual discharge of force at F, to enter the third set of vanes C, these latter revolving in an opposite direction, so the speed of rotation of any set of moving vanes will be reduced accordingly. If the vanes C are fixed, and discharge into a fourth set of vanes D, the rate of rotation can be reduced again as the square root of the water's velocity in the two cases. This is the manner in which the speed of stage turbines is reduced.

The vanes A and B may represent a common water turbine. With the vanes C fixed and those at B and D moving, we have a two-stage steam turbine, except that in all cases the buckets or vanes, whether for steam or water, are of ellipsoidal or other modified curves.

Water turbines of this class have commonly only two sets of buckets or vanes, A and B, for example, one fixed and the other movable. Stage steam turbines have from 5 to 10 sets of vanes, the mobility of the fluid demanding this difference. All motors of this class are called "filled," the induction and eduction passages being approximately of the same size in the case of water wheels, but increased, of course, for elastic fluids to accommodate their expanded volume.

One other class of motors remains to be noticed, viz: the reaction type. Their manner of operating will be more clearly explained later on.

These remarks will, I hope, explain the classes or types of steam turbine motors as now made and in course of evolution; and, with this much respecting the principle or mode of their operation, I will turn briefly to their history and afterward discuss the constructive problems, which, as at first explained, form the principal theme to be dealt with at this time.

It is common to begin the history of steam engines with an account of the "æolipile," made in Egypt about 2000 years ago, by Hero, a Roman architect. This device, with which almost every one is familiar, is illustrated by Fig. 3.

It is an organized steam motor, much better than some made at this day; and, considering the circumstances of the time, was a wonderful production, evincing, as it does, a knowledge of the expansive force of steam; also the principle of reaction. A is a rotative steam-containing vessel, B B are hollow arms delivering jets of steam tangential to the path of revolution C. Supposing the vessel A to be filled with steam from a pipe D at a pressure of 100

pounds per square inch and the area of each jet to be 0.1 inch, or together 0.4 inch, then the pressure on these orifices, if closed, would be 40 pounds. When open, there is no pressure on this area, but an unbalanced back pressure of 40 pounds in the opposite direction, the turning force, due to reaction or unbalanced pressure.

I am aware that a mathematical treatment of this matter would involve the ponderable matter discharged, its velocity and other intricate conditions; but the theory of unbalanced pressure will answer for present explanation.

This Hero wheel was a reaction turbine, and, as such, was a much more complicated and ingenious conception than the direct acting or impulsive wheel of Branca, which followed in 1629, about 800 years after Hero's æolipile.

This latter device can scarcely be considered an invention; but it must be remembered that the expansive force of steam was, even

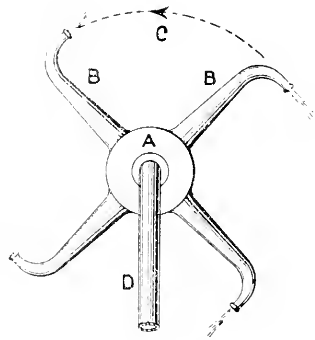


Fig. 3.

at that date, a mystery. No useful application of this device is known, and it was only a toy, consisting of a wheel with flat vanes against which a jet of steam impinged.

From this point the art seems confined to England, or mainly so, and from 1784 to 1901 there were granted in that country more than 400 patents for machines that may be classed as, or with, steam turbines. These various patents have been recently examined and listed by Mr. Robert M. Neilson, an engineer of Manchester, England, who has arranged a chronological list of them in a treatise on "Steam Turbines," published last year.

Even James Watt, John Ericsson, Perkins and other well-known steam engineers "had a try" at these obdurate machines without permanent result, and an inference, to be drawn from the copious array of schemes proposed, is that the principal impediments were in various operating conditions now better understood and

mainly the want of resources for constructing machines to move at such great velocity.

There is also the fact that, in so far as principles or modes of operating are concerned, these inventors anticipated about all that is known in the present steam turbine practice, except in the respects just named.

Kemplein's engine of 1774 was a reaction one, with the arms and vents as in the æolipile of Hero. James Watt's machine of 1784 was similar in operation, with this difference, that he proposed to vent the steam under mercury or other fluid. Sadler in 1791 devised a compound machine or one of double action, also of the reaction type. Trevethick in 1819 proposed a reaction machine, and John Ericsson in 1830 patented a very well-designed reaction wheel.

In 1843 Pilbrow patented a stage turbine with a large number of fixed and moving vanes or buckets arranged for expansion. Indeed, his machine had all the main features of modern engines of the stage type.

In 1848 Robert Wilson patented the first radial flow steam turbine, which in design fully anticipates the Dow and other radial flow machines of our time. He also proposed a parallel flow engine with expanding chambers or spaces, in the manner of Parsons.

In 1888 Alexander Morton, a well-known engineer of Glasgow, Scotland, made experiments with a steam turbine of ingenious form, and other inventors in Scotland made reaction machines that were said to be applied to practical work; but undoubtedly the principal part in the history of reaction engines was the invention of William Avery, of Western New York, who, about 1825, made and put in successful operation a large number of such engines.

Mr. Avery was a near relative of Prof. John E. Sweet, President of the Straight Line Engine Company, of Syracuse, New York, to whom I applied some time ago for information respecting the Avery engines. Professor Sweet replied as follows:

In respect to the history of the Avery engines, these were made 75 to 80 years ago by William Avery, a local mechanic here. There were about 50 constructed and put in use. One of the runners is now in my possession; another, that I saw years ago, had a hollow shaft of perhaps 1¼-inch bore. The head or runner was of sword shape, the arm 1 by 3 inches at the center and ⅜ by 3½ inches at the ends, the diameter swept being about 5 feet. Steam was admitted through the shaft by means of a stuffing box, passed through the shaft to the hollow arms and escaped at a tangential issue ⅛ inch by ¼ inch, at the rear corners of each arm, the ends of which were stopped by plugs brazed in. Owing to the rapid rotation of the arms—10 to 15 miles per minute—the front edges were so rapidly cut away that replaceable blades made of tempered steel were inserted so they could be renewed. The fact that the engine had to be taken to a blacksmith shop every 3 or 4

months for renewal or repairs had more to do with their abandonment than their lack of economy. As to the latter, people who knew the facts, or claimed to do so, said that when they changed to the common slide-valve engines there was no gain in steam economy over the Avery engine.

Another feature that worked against the Avery engine was the stuffing box around the shaft, which in the hands of workmen of that time was apt to be set up so as to consume a large part of the power in friction. This was a natural consequence, as the wear was rapid. What the result would have been with a truly ground shaft in a metal bush, instead of a turned shaft and stuffing box, making the issues expanding nozzles and multiple expanding by 2 or 3 arms in separate cases and connecting to a condenser, is not known. It might rival a pretty good modern engine, if not the best.

The Avery engines were used in saw mills and woodworking shops of the time. They had weak starting power, and did not need much for the uses named. They ran at such a fearful speed that the reducing motion was an impediment. Mr. Avery had to employ bands, which were far more objectionable than gear wheels.

The Ruthven and also the Gorman engines of the same type are mentioned by Prof. Rankine in some of his writings and claimed as attaining an economy equal to piston engines of the time.

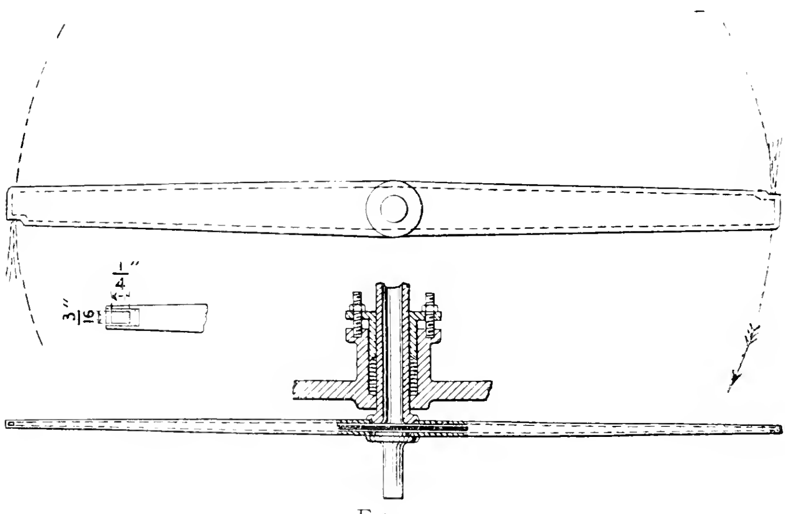


Fig. 4.

Professor Sweet sends, with his communication, a drawing of the Avery impeller in his possession. This is shown in Fig. 4, and it must be admitted that the circumstances described, as before remarked, form a principal fact in the history of free-running engines. The economy attained, even if there were no other fact than that of 50 or more engines being made and put into practical use, is enough to amaze one when it is considered that the engines were purely reactive like a Barker water wheel or the Hero engine in Fig. 3, and that the inert fluid under atmospheric pressure was left

directly in the path of the impeller's arms, and wore away the front part where the pieces were inserted. The casing was no doubt of a form to prevent free revolution of the spent steam, otherwise this impediment would to a great extent have been avoided.

This machine admits of further comment, especially in its constructive features, and I have no hesitation in claiming that the material is in this case better disposed to resist centrifugal strain than in any steam turbine now being made. The speed was no doubt equal to that of machines now constructed. The structure is not exposed to incomputable inherent strains, as continuous wheels or disks must be, and the box section, made of thin metal plates, is the strongest known in the arts.

In a letter received from Mr. Charles Brown, of Basel, in 1903, I find the following remarks respecting the Avery engine:

> Early in the forties an American engineer by the name of Pratt told me that he had experimented with two of Avery's Hero reaction wheels, one with 100 pounds steam running at 45,000 feet per minute. It gave 30.3 horse power and consumed 7½ pounds per horse-power hour, and another with 130 pounds steam giving 24½ horse power consumed 6.16 pounds running at 54,000 feet. Diameter at nozzles 5 feet. If these data are correct the result compares well with a 30 horse-power Laval, which, non-condensing, consumes fully as much coal as the old Avery. Pratt told me that Avery had built a locomotive with his wheel. Avery's engine had the advantage over the Laval that the number of revolutions, 2800 to 3600 per minutes, are so low that it might be used for driving many machines without the intervention of gearing, so that it might be worth while to take up the study of the Avery again, for the wear and tear of the Laval gearings is heavy. For heavy work, the Parsons is not likely to be superseded for some time yet. Brown, Bouverie & Co. are crowded with orders, and the works are in a chronic state of expansion; the large sizes are so much more economical that the piston people have no chance. Latest test gives 8 pounds per indicated horse-power hour.

The next step in practically applying the free-running steam wheel to useful purposes was, so far as I know, by Dr. De Laval, of Stockholm, Sweden. I was often in Sweden during the earlier experiments there, and imbibed a curiosity and interest in this matter that has lasted ever since, especially since coming in contact with the tangential type of water wheels on this coast. These latter are operated under pressures much greater than has been attempted with steam motors; that is, up to 900 pounds per inch, giving a velocity of 120 feet per second. I believe, and I shall attempt to show, that such wheels are made on a system much in advance of steam turbine practice in some very important respects.

Following Dr. De Laval and perhaps others in steam turbine wheels of single action, came a successful division into stages by Hon. A. C. Parsons, one of the most eminent steam engineers of our

time. This subdivision, it may be called, of the steam turbines, had for a principal object, as before pointed out, a reduction of the speed of wheels and their adaptation to direct driving of dynamos, marine pumps, screws and the like, offering uniform resistance or load.

Wheels or engines of this type involve the maintenance of running steam joints between the stages, and demand workmanship that is now and will likely remain a bar to their general manufacture. There is also an inability to endure lateral stress on the spindles, because the running steam joints that separate the stages of pressure have a clearance of about 0.01 inch. These latter features have confined the engines to purposes where simple torque is delivered, but this, includes a great part of the whole field of motive power.

Parsons's modification of these engines has called out scores of inventors and imitators in this and other countries, and it seemed for a time as though the De Laval engines were to remain sole representatives of the single-action system; but a reaction has began, most notably in Germany, where Professor Riedler, the author of "*Indikator Versuche auf Pumpen*" and much other noted work, has, in conjunction with Professor Stumpf, produced single-action engines up to 2000 horse power, apparently of durable but expensive construction. I have drawings of these engines, accompanied by German text, with a list of engines in operation up to November of 1903.

There have been scores of abortive attempts in single-action machines, and no doubt there will be many more, because the problem, as a constructive one, offers a fertile field for the contriver incapable of understanding the impediments to be overcome.

The mechanical construction of machines should be approached by analysis of their operating conditions.

These latter are not amenable to computation, except a few, such as the strength of material, normal strains, endurance or wear and so on; but beyond these things lie what may be called the "phenomena of operation," that must be learned by observation, inference, analogy, and, for the most part, empirically.

To illustrate what I mean: The generation of electric current by dynamos was a well-founded science long before there were durable and reliable journal bearings for the armature spindles, and these are now a survival from endless modification. The commercial factors of symmetry, cost, endurance and many other qualities belong in the same category and are not computable.

It is not usual, in papers of this kind, to introduce the subject of constructing and operating machines, and it might be out of

place in papers relating to some kinds of machines employed in the arts; but, as before pointed out, information on this subject is, at this time, the lacking element in steam turbine practice.

At the risk of prolixity I will summarize, and restate in a compendious way the points already gone over, and then proceed to constructive features.

All fluid machines belong to two classes:

First, machines that receive and translate the force of fluids or motive engines of all kinds. Second, machines to impel fluids, including pumps of all kinds. This is a division easily understood. Fluids include air, steam, water, gas, all of which come under and are amenable to certain ascertained laws, and are divided into elastic and inelastic fluids.

Fluid motive engines are divisible into two classes—positive and free running. The positive class includes all that operate with pistons and which measure, positively and in proportion to movement, the amount of fluid that passes through them. There is no time factor in positive-acting machines; hence the rate of movement and the work done in a given time are under control. Within certain limits a positive-acting machine may run fast or slow, and its speed can be varied at will. The latter is the most important advantage that positive or piston machines have over the impulsive or non-positive type, and lends itself to a wide field of uses.

This advantage of a variable rate of movement is, however, diminishing all the time, because of the improvement in transmission gearing, designed to change the relative rate of movement.

The free-running class of fluid machines, those which operate by impulse and reaction, have a "time function" to deal with, and their speed is a determinate quantity, based upon the flowing velocity of the impelling or impelled fluid. This class embraces water wheels of all kinds—gravity, impulsive and reacting; also steam turbines.

The velocity of this impulse class of machines is inversely proportional to the density or weight of the fluids that impel them. A centrifugal pump and a rotary fan seem very different machines, but they operate according to the same law, and their speeds are inversely proportional to the weights of the fluids, or as 800 to 1. This indicates the great velocity at which single-action steam turbines must move, practically about 90,000 feet a minute.

Such a velocity produces various phenomena, such as the disturbance and stretching of the rotative parts by centrifugal strain; tendency to vibration, noise, the heating and wear of journal bearings and other things. The centrifugal strain can be imagined when we reflect that 1 pound of metal, on the periphery of a wheel

2 feet in diameter, will, at a speed of 10,000 revolutions per minute, represent a centrifugal force of 34,000 pounds or 17 tons.

Referring now to the constructive features of steam turbines, the first thing considered will be the buckets, and at the beginning I will claim that these are at fault in modern practice because of being curved in one plane only; consequently they have but one correct position in the jet throughout the whole arc of their movement and in nearly all cases are cut out of solid metal, and have angular or imperfect corners.

This form of buckets is due no doubt to the difficulty of machining their surfaces except in straight lines, but it produces, in turbine wheels, several features of construction that are far-reaching in effect, also far from apparent until carefully examined.

First. It increases the weight and number of buckets about fivefold in the attempt to secure impingement of the steam jets normal to the straight faces of the buckets.

Second. It distorts the course of reaction from a possible angle of 15° to an angle of 20 to 30° required to secure clearance.

Third. It makes necessary a side application of the jet, introducing lateral stress on the wheels and inducing vibration.

Fourth. It augments, in proportion to the added number of buckets, the amount of fluid friction.

Not to include the resistance of corners.

Fifth. The disposition of material in solid disks prevents the employment of its fibrous or laminated nature in the direction of strain and demands very expensive homogeneous material, a result indirectly of the numerous buckets.

This is a bold arraignment of certain constructive features, and would require great temerity on my part to bring forward were I not fortified by something stronger than inference and personal experience in this matter. I allude to the tangential water wheel practice on this Coast, which has passed through a crucial course of development that furnishes copious suggestion for single-action steam turbines.

The number of buckets is a very important matter. It is a sequence of the angle of impingement, and this again is a sequence of the bucket's shape, as will be shown further on. The surface or fluid friction, which offers a considerable resistance and loss, is in proportion to the number of buckets employed, and should be considered in this connection.

Most of the steam turbine buckets now made have angular corners, and, when there are not such corners, the end walls of the buckets are so distant from the jet as to lose reactive effect in that

direction. We long ago learned to keep water out of sharp corners in buckets.

In respect to the number of buckets or vanes, Fig. 5 shows how the line of impingement varies in respect to the straight faces of radial buckets, being as the sine of the angles A and B; and there is no way of securing impingement even approximately normal to the straight faces, except by employing a large number of buckets set close together. The result is much the same whether the jets be applied on the side or tangentially, as shown in Fig. 6, where the angle of entrance is 26° and that of discharge 36°.

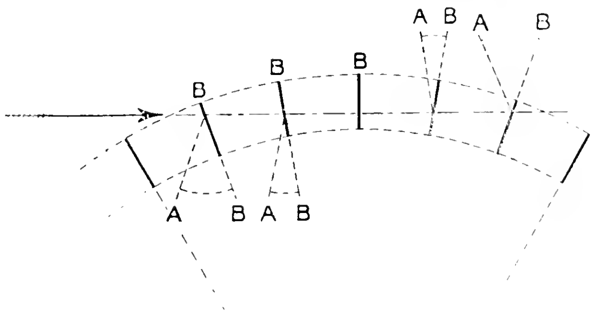


FIG. 5.

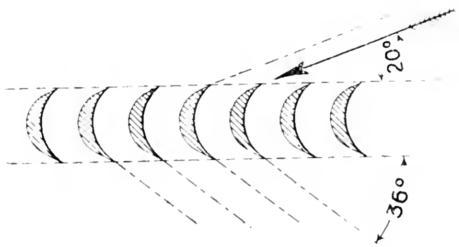


FIG. 6.

The trend of practice in tangential water wheels has been to wider spaces between the buckets, better angles for discharge, and, recently, to uniformly curved buckets, as hereinafter explained.

This feature of oblique impingement is accountable for at least three-fourths of the buckets now employed, and the result is loss by increased surface friction and distortion of the angle of reaction.

Fig. 6 shows approximately the entrance and discharge angles in the De Laval engines, embracing an arc of 56°, which, by reduc-

ing the number of buckets, could be reduced to 36° or less if the problem of oblique impingement were out of the way. Fig. 7 shows spacing for tangential buckets to secure an easy discharge at 20°.

In the Riedler turbines, the angle of discharge is 180°. In other words, the discharge is opposite the jet, but this calls for increased surface, more width and weight for the revolving member, and expensive work in construction, which are hardly offset by countervailing advantages, and which certainly prevent a cheap and general manufacture of the machines. It would not be becoming in myself to criticise the computations and designs of Professor

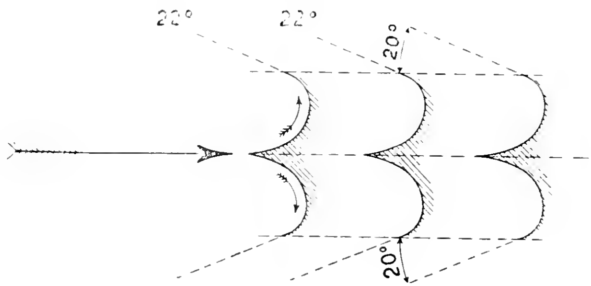


FIG. 7.

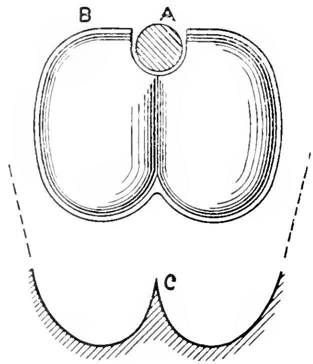


FIG. 8.

Riedler, but I am looking at the practical and mechanical phases of the problem, and seeking means whereby such engines may be made at a reasonable cost by common facilities and operate at reasonable efficiency.

The contention is that the buckets of steam turbines should be curved in all planes approximately as shown in Fig. 8, taken from a form of water buckets of a very advanced type by Mr. W. A. Doble of this city. These are of double concave or cup form, in order to permit direct and balanced impingement at the various angles in which they are presented to the jet, and have a central dividing

wedge to permit tangential application. This latter is not presented as a new idea, being simply the final form and method for tangential water wheels on this coast, after more than 25 years of continuous experiment and the attainment of an efficiency that is, if not final, so nearly so that a very narrow margin of avoidable losses remains.

If there exist any reasons why this same system or method of operating is not applicable to buckets for steam, I am not able to perceive it. Of course, expansion of the steam and divergence of the jets would call for modification not determinable until a form of nozzle and the contour of the jet are assumed.

Not knowing how far the contour of a jet of steam will permit its passage through notch A, in Fig. 8, I am not able to say how far this feature is applicable to an elastic fluid, or how far such a passage as that at A would become a spillway when a jet was impinging at the opposite end of the bucket. I will not discuss this here, further

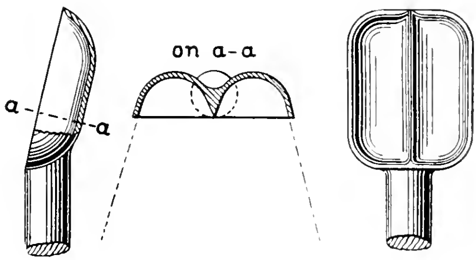


FIG. 9.

than to point out that this passage A avoids passing the rim B of the bucket through the jet and the disturbance that must result from this cause.

The dividing wedge C permits tangential application of the fluid and produces a shallow and balanced discharge. As a feature of impulse fluid motors, it has not met with analysis and adoption except on this coast and in the Riedler steam turbines. Its function, or rather its effect, is not always understood. The avoidance of side stress on wheels, especially on steam turbines at their enormous speed, is important, and so is the dual discharge which permits a more nearly uniform velocity throughout the discharged water section, because the latter is shallower. After many years of practical experiment, as well as some spent in scientific work, the dividing wedge was confirmed at the University of California in 1883* as a permanent feature of good practice for water.

In Fig. 9 is shown a form for buckets capable of receiving and

* Partial Turbines or Tangential Water Wheels. College of Mechanics, Berkeley, Cal. By Ross E. Browne.

properly reversing a jet of steam coming within angles A and B, and permitting the number of buckets to be reduced to what will come within and cover the divergence or expansion of the steam jet, or about 1 bucket for each 8° of arc for wheels from 20 to 40 inches diameter. This is less than one-fifth the number now employed for wheels having buckets straight in one plane, as in Fig. 6.

Such buckets can be stamped out of fine steel and made strong, smooth and integral with their radial supporting stems. They can be made of uniform thickness, with no more metal than their operative functions require, and of less than half the weight of those cut from solid metal, so that, compared with the usual form of steam turbines, there would be one-fifth the number and (excluding the fastenings) less than one-half the weight, so that the mass in the rim of a turbine wheel with this form of buckets can be reduced to one-eighth or even one-tenth of that in common practice.

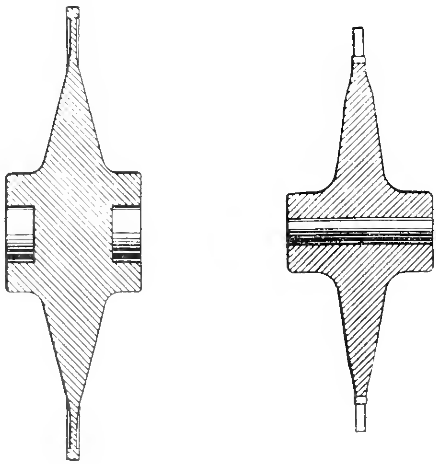


Fig. 10.

In the construction to be hereafter suggested, the buckets represent and constitute the whole rim of a wheel.

As to wheels or disks, nearly all now in use for single-action engines are solid disks, as shown in Fig. 10, a matter much to be wondered at if we consider the strains. Not everyone has had the opportunity of seeing disks at high revolution, circular saws, for example, which, at a speed of 10,000 feet per minute, assume a sinuous path at their peripheries and lose their stability by stretching.

A bucket, weighing an ounce, and revolving in a circle 24 inches in diameter at the rate of 10,000 revolutions per minute, will exert a centrifugal strain of 1 ton, and its supporting sector and

fastenings will exert 50 per cent. more—a result scarcely conceivable. The disposition of mass, strains and section may mathematically produce a body of the spindle form shown in Fig. 10 and in all diagrams that have been worked out by computation, but I do not believe that practical experiment will evolve anything of this kind.

Assuming this centrifugal force applied to a sector of a solid disk of uniform section, a circular-saw plate, for example, the error of such construction becomes apparent. The disposition of the material, in a sector of the wheel of which the bucket is the outer end, will be inverted, so to speak, and disposed inversely as the strain. The perimeter has no function requiring a continuous mass there, unless it be to hold a series of buckets set close together or to provide mechanical fastenings for them.

To compensate this contradictory disposition of material, the wheels are commonly made in lenticular form, as shown in Fig. 10, so that the mass of a sector is approximately a radial body of nearly equal section, apparently providing for centrifugal strain if change by elongation is ignored; but this latter is the principal fact of all, and one which cannot be provided for in a solid disk of any form, because the conditions are not ascertainable. I have made diagrams to show the mass, in 10° of arc, for several forms of wheels, but want of space prevents their reproduction here.

I have had made, by a very competent engineer, an analysis of the strains in several forms of solid disks, independent of elasticity and of change by stretching, a condition that defies computation in metal forms of the kind. It is an interesting and also an intricate problem, but I believe of but little practical value.

A very extensive analysis of such disks or wheels, made by Mr. Frank Foster, was published in *The Engineer*, London, No. 2506, January 8th of the present year. It is a study in mathematics of a very abstruse and no doubt interesting nature to students in calculus, but the weight and cost of such disks, if there were no other reasons, preclude their use for plain simple engines, such as those to which these remarks are directed. Professor Riedler seems to disregard such theories respecting the disposition of material in his disks.

I have shown how four-fifths or more of the weight in the periphery or rim of such wheels can be dispensed with, and I will suggest for the body of the wheels a construction which will eliminate inherent strains due to elongation or stretching, and at the same time dispense with the greater part of the mass and reduce the centrifugal strain accordingly.

In wheels moving at such high velocity, certainly the first thing

should be to remove from the disruptive zone all joints and mechanical fastenings. These must necessarily include an extra mass of inert material at the points of juncture, plus bolts, rivets or other means of attachment. Buckets or other parts fastened by dovetail joints are open to the same objection, because extra substance must be added to endure compression and holding strain.

The construction shown in Figs. 11 and 12 is suggested, the buckets being made independent, avoiding circumferential strain and permitting free elongation by centrifugal stress. The spokes B are tapered, so that their sections will stand the centrifugal strain within the mass lying outside of any point. They are fastened in a nave by welding or by suitable mechanical means, the strength of which will equal their section.

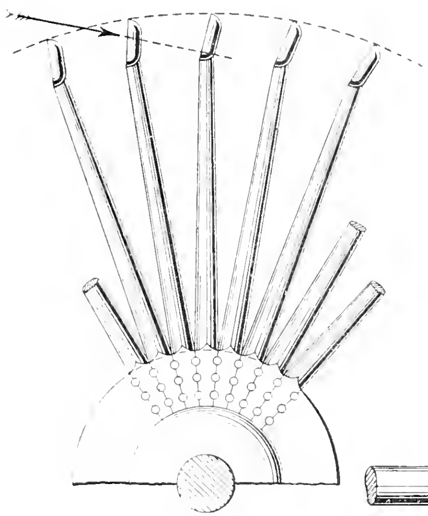


Fig. 11.

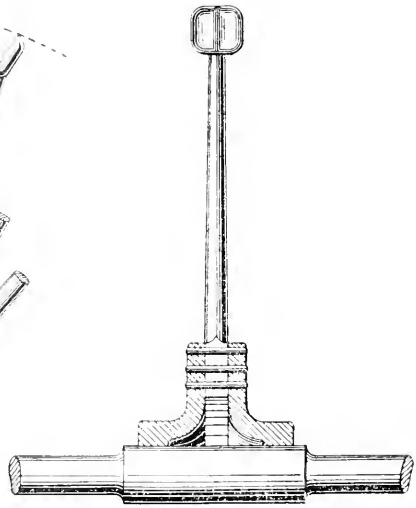


Fig. 12.

The nave of the form shown in the diagram will not expand and become loose on a spindle with the amount of weight in a wheel constructed as shown.

In respect to gearing for transmission, I believe that the principal impediment is a want of confidence. Nowhere in the arts have we been called upon for translation at such high velocity; consequently we are not prepared to provide devices such as are required to reduce the speed of single-action steam turbines, where the elements of transmission have to move from 4000 to 6000 feet per minute. I know of no reason why plain tooth wheels, or tangent gearing, will not run at this speed, and I confidently expect that they will do so without any objectionable result.

Respecting tooth gearing there is much apprehension, which arises from the difficulties of constructing it in perfect form. In the Continental Hotel in Philadelphia a screw elevator was in use for more than twenty years. A bevel wheel of 5 feet diameter and a pinion of 10 inches diameter drove the screw, and they were absolutely noiseless. They were made at the Industrial Works in that city, where I was working at that time.

In an experiment made many years ago, at the works of William Sellers & Co., to test the ultimate speed of transmitting apparatus, bands of one kind or another were employed up to a point of failure, then plain spur wheels were resorted to, and, as I have been informed, they were entirely successful to the point of disrupting a steel disk driven by the gearing. Of course, such gearing to run without noise must be perfectly made; and, if there is reason why they will not transmit at 4000 to 6000 feet per minute, I fail to conceive it, especially when inclosed in the turbine wheel chamber, as hereafter suggested.

Twenty-five years ago I constructed machines in which bands of flax webbing ran at 6000 feet per minute without difficulty.

These bands drove spindles at 12,000 feet per minute, and the machines are yet in use in Columbus, Ohio, where they were made in what might be called a country shop.

For a good many years I was engaged in designing and making machines in which the spindle bearings had a velocity of from 2000 to 3000 feet per minute, were subject to lateral strain and mounted in weak framing, and they ran cool when the fit and alignment were good. Consequently I am in no way alarmed at the requirements in steam turbine practice, and I confidently expect to see power transmitted by bearings moving at a surface velocity of 5000 feet per minute and spindles run cool at 10,000 to 15,000 revolutions per minute.

In my opinion, the gearing of transmission should be inclosed with the motor wheel, and should operate in the vapor contained in the casing, that being open to a condenser. There are three reasons for this: (1) The better performance and wear of wheels when steam lubricated; (2) the absorption of noise, if that be present; and (3) the avoidance of packing glands on the spindle of the motor wheel, a very objectionable feature, present, I believe, in all the steam turbines now made.

Such packing glands are objectionable not only because of a possible resistance and loss of power by friction, as pointed out by Professor Sweet, but because they permit the entrance of air into the condenser and involve the wear and care of packing.

The interior of the wheel casing should be annular, turned smooth and otherwise so arranged as to permit the free revolution of any vapor it may contain. It has been suggested that a sector or spoke construction of the wheels would cause serious resistance by windage or fanning the steam or vapor in the casing; but the attenuated vapor in a casing, 10 to 12 pounds below the atmosphere, would not offer much resistance if fixed, and perhaps none to consider at all, if free to revolve with the wheel.

In respect to bearings for the wheel spindle, these should be parallel, hardened and ground, mounted in pivoted split shells of cast iron, and, like the reducing gearing, inclosed in and exposed to the vapor of the wheel chamber. This may seem objectionable because of heat, and it would be so in machines as now arranged, with the casing exposed to a high temperature.

This latter I believe to be a mistake. No avoidable heat should be communicated to the casing to raise its temperature above that of the expanded steam. A low temperature would not cause appreciable thermal loss in the jet, but would assist a condenser and conduce to other desirable objects that have been named.

In respect to nozzles for buckets, such as have been suggested, it is a difficult subject without experiment and when the contour of a jet at different pressures is not known. I am of the opinion, however, that if inclosed the tube should conform to the natural contour of the jet. With side application of the steam on buckets flat or straight in one plane, there is no doubt a gain results from the use of a diverging nozzle, but in buckets in which the jet is divided the case is different.

On the whole, I think it safe to assume that the form of nozzles for steam turbines of the single-acting type is not a problem that will much interfere with their successful construction. That there should be a converging anterior chamber, a throat to determine volume and a diverging nozzle is obvious, but further than this the result is no doubt a refinement that has more importance in a mathematical theorem than in the workshop.

Some years ago, I think in 1901, I asked Mr. Brown, whom I have several times quoted, his opinion respecting steam-motor nozzles. He replied as follows:

> As regards the De Laval nozzles, the learned here are of various opinions as to their value. Professor Meyer, in Zurich, who has experimented long with the De Laval, says that it is in no way superior to a common nozzle.

The views and suggestions which I have had the privilege of advancing here have been imperfectly embodied in an organized mechanism, shown in Fig. 13. This drawing was made about two

years ago, and it would be modified in various ways if reproduced now. It, however, embodies most of the features that have been suggested.

I presume this presentation of a subject, without the scientific furtherance common at this day, can hardly be considered a conventional contribution to the art. It may not be so accepted, but I venture the prediction that the evolution of cheap steam turbines, adapted for general manufacture and use, will before long result from effort and experiment on the part of intelligent and experienced mechanics aided by scientific data.

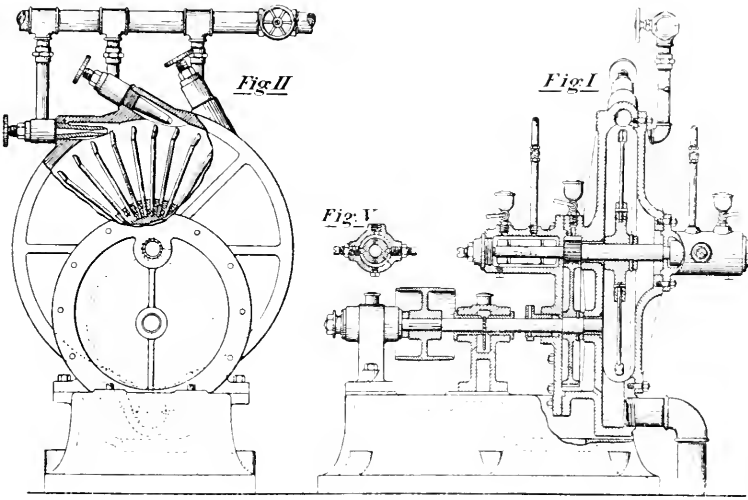


FIG. 13.

This assumption has some answer in the fact that, already mentioned, 75 years ago Mr. Avery, a country millwright in Western New York, made successful reaction steam turbines, and applied a large number of them successfully to common rough uses. He also made impelling members which contained about one-tenth of the material now employed, and, as I believe, in a more practical manner than in many wheels now being produced. The work was done in blacksmith shops, at a time when accurate tools and processes were almost unknown, and I am much inclined to agree with the opinions of Prof. John E. Sweet, whose skill and judgment no one is likely to question, who, in a recent letter to the author, said: "If I were to engage in the manufacture of steam turbines I would begin with the Avery one."

The steam turbine practice of our day is the finest example of constructive engineering work that the world has ever seen. It is

confined to large units, not because of operative impediments in small engines, but because these cannot be furnished separately at such prices as can be obtained.

From these premises I conclude that future steam turbines for common use will be single acting and condensing whenever possible, with wheels of sector construction as light as can be made. There will be no packing glands on the main spindles, and the first movers for transmission will be plain spur or tangent gearing.

I will conclude this paper with brief mention of the economic results that have been reached with steam turbines, as illustrated by the generating engines recently constructed in Switzerland, one with very high-class piston engines and one with turbines, each of 5000 horse power. The results were as follows:

Weight of piston engines and generators, 598 tons. That of the turbines and generator only 78 tons, or nearly 8 to 1. The steam consumption by the piston engines was 11 pounds per indicated horse power, and for the turbines 1 kilowatt with 14 pounds of steam, or about 10 pounds per horse power. Oil consumption was as 20 to 1 in favor of the turbine, and attendance about 5 to 1.

The piston engines were made by Messrs. Sulzer Bros., of Winterthur, and the turbines by Messrs. Brown, Bouveri & Co., of Baden, in Switzerland. The quantities were furnished to me by Mr. Brown, of Basel, Switzerland, with whom I had personally discussed the subject some time before the tests were made and who had forecast the result with much accuracy.

THE RECLAMATION OF A MOUNTAIN SWAMP.

By Marsden Manson, Member of the Technical Society of the Pacific Coast.

[Read before the Spring Meeting of the Society, May 27, 1904.]

[Note.—The execution of this work has been very actively and ably carried out by Mr. Ralph E. Parker. He has made all surveys, and has laid out and constructed the main canal and irrigation ditches and the temporary and movable dams. The writer is indebted to him for the data concerning construction and cost.]

The features with which this paper deals lie in Harney County, Southeastern Oregon, and in the broken and upheaved southern portion of the Columbia Lava Plain. This lava plain has been elsewhere described by the writer (*American Geologist*, Vol. XXIV, 1899, pages 203-209). It covers large areas in Washington, Oregon, California, Wyoming, Idaho and Nevada, and dominates the physical geography and topography of over 150,000 square miles in these States.

The drainage areas and swamp with which we have to deal cover about 450 square miles of a block of lava some 1000 square miles in area, and from 1 to 1¼ miles thick. This broken, tilted and distorted block lies between 2 nearly parallel faults some 25 miles apart and over 40 miles long. The upthrust along the easterly fault is apparently 1 mile or 1¼ miles, and constitutes the bold feature known as Stein Mountain, which reaches an elevation of 11,000 feet above sea level. The easterly slope of this mountain shows a broken and precipitous front, rising above the general level about 1 mile or 1¼ miles, and showing that the lava has approximately this thickness. The westerly slope is a gentle descent of about 5°, partly dissected by rifts and gorges in the lava, and terminating in low bluffs of basaltic lava bordering the easterly side of Blitzen Swamp and rising a few hundred feet above its level. On the westerly border of this swamp and marking the position of the westerly fault plane is another bold escarpment, locally known as "Jackass Rim Rocks," where the vertical movement has probably been 800 to 1000 feet.

Donner and Blitzen Rivers and several minor streams drain about 400 square miles of the west slope of Stein Mountain. In their upper reaches they occupy deep gorges, in which snow drifts and packs in the winter. Snow also accumulates in the thickets of dwarf aspen which grow wherever the soil is deep enough to give roothold. The precipitation upon this drainage area amounts to about 15 inches per year, mostly in the form of snow. Rapid melting in the spring and early summer causes the floods which reach

Blitzen Swamp. Low-water discharge is furnished by springs in the gulches. Accurate hydrometric data were not available, and as the projected reclamation contemplated the use of the swamp lands for raising hardy forage grasses for hay and pasture, short periods of flooding could do no harm. The features above mentioned are given an outline expression in the accompanying sketch map and general sections.

BLITZEN SWAMP.

Blitzen Swamp thus lies in the valley depressed between these 2 basaltic rim rocks, and extends into the lower ends of their lateral gorges. The total area is about 50 square miles, having a length of 22 miles and a mean width of 2.5 miles, and an elevation of about 4500 feet above sea level. The entire valley is about 32 miles long. The swamp is naturally divided into 4 sections—*the Upper Swamp, the Gorge, the Lower Swamp* and *Diamond Swamp*, the latter being an extension into a gorge on the easterly rim rock or lava escarpment.

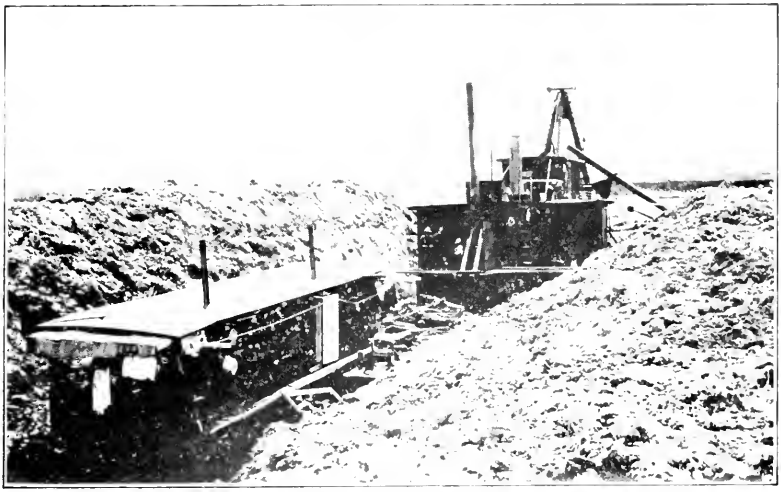
The fall through this valley is not regular, and in the aggregate amounts to 95 feet, 35 feet of this fall being in the upper 7 miles, 25.8 feet in the canalized portion and the remainder in the river to Malheur Lake. The surface of the valley presents all stages of the process of development: (1) Cones of cobble and gravel merging into alluvial lands overgrown with brush. (2) Tule, flag and canebrake swamps, with peat soil resting on a peaty, loam or clay subsoil. (3) Floating islands or "blankets" of peat, on which tules, flags and aquatic plants flourish. (4) Ponds and lakes deeper than the level of proposed drainage. Irregular channels meander through the entire area. In some instances these channels were concealed beneath floating blankets of peat. These blankets were cut up with hay knives and dragged ashore.

The upper portion of the upper swamp has received sufficient sediment to give it steeper gradients, and has been partially cleared and drained and converted into very valuable hay and meadow lands, which are well irrigated. It is not proposed to extend the canal into these lands, as the natural channels have already been improved by scraping them out and by rough rectifications. The main canal will intercept these channels about the middle of the upper swamp. The remainder of the swamp is principally a vast tule swamp, with peat soil and a peaty or clay subsoil.

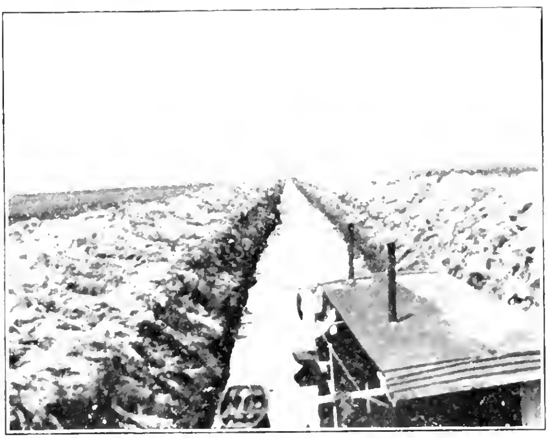
These features are made clearer by the accompanying map, sections and illustrations.

At the lower end of the swamp the basaltic blocks or rim rocks

Busse Irrigation Ditch under Construction.

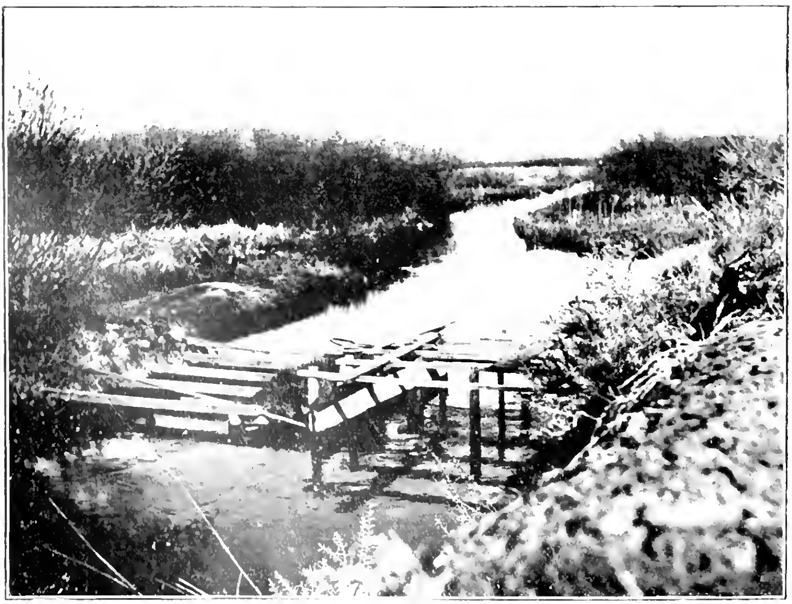


Dredger "Blitzen" and Ark



Main Canal, Looking Down from Dredger

FRONT VIEW OF DREDGER, MIDDLE SWAMP.



MIDDLE SWAMP.

fall back and inclose low, flat benches of arid land covered with sagebrush, and aggregating some 15 or more square miles. Over about 12 square miles of this land it is possible to divert water for irrigation.

The writer was called upon to advise as to the possibilities of drainage, the size and location of canals, the type and power of machinery to use and the possible diversion of the drainage waters for irrigation. The problem presented interesting and important features:

First. The drainage of an elevated swamp of considerable area and restricted outfall.

Second. The control of this drainage so as to give broad or subsurface irrigation over the drained area.

Third. The use of the drained-off waters for the irrigation of arid land. This feature was of high importance, by reason of the partial reclamation of the lands bordering Malheur Lake, at the outfall of the Blitzen Swamp. The natural disposition of the spring and early summer floods was principally by evaporation from the 50 square miles of swamp surface.

After an examination of the field of operations and of all data available the summary of the report to the owners was that:

(1) The drainage of the greater portion of the swamp was practicable with a well-aligned main drainage canal having the general fall of the swamp and a sectional area of 260 square feet, but that for short periods of excessive flood partial submergence would occur; that such auxiliary canals as might be found necessary might be considered after the construction of the main canal.

(2) That the waters drained from the swamp should so far as possible be used for the irrigation of the arid lands bordering the lower swamp.

(3) That the best type of dredger to be used was a dipper dredge, with a bucket 1¼ cubic yards capacity and a delivery 45 to 50 feet from the center of the canal, the following details of machinery, etc.: Fifty horse-power boiler, locomotive type, 44 inches x 11 feet, large firebox and doors (woodburner). Two engines, 10 inches x 12 inches, for operating crane, 7 small auxiliary engines for hoisting spuds, etc.

Maximum weights were as follows: Crane 8 tons in 3 parts, 2⅔ tons each.

Boiler, naked, 7000 pounds. Other parts easily handled. (These parts had to be hauled about 200 miles.)

The hull was designed to be 24 feet x 75 feet x 6 feet, but was reduced to 19 feet x 75 feet x 6 feet. As lumber had to be hauled

60 miles from the Blue Mountain Mills, detailed bills of lumber were made out, and equal care and economy were necessary in all ironwork.

The estimated capacity of this plant was as follows:

Under ordinary conditions, 30 linear yards per day of channel, 3 yards deep, 8 yards wide slopes $\frac{1}{1}$, or about $\frac{1}{3}$ mile per month.

Under favorable conditions, 55 linear yards per day, or nearly $\frac{2}{3}$ mile per month, or the entire 13.2 miles of canal in 24 months' work.

It was recommended that where the conditions permitted, that the swamp be cross-sectioned 1000 feet apart, and the canal line located along the lowest ground and most direct alignment, and the ground sounded particularly in the "Narrows," to avoid possible cutting into submerged masses of lava.

The cost of machinery and hull was estimated at $9750, to which was added freight to Winnemucca, hauling to the site an ark or quarter boat and 2 wood scows, costing $8200, as follows:

Freight from Marion, Ohio	$2,100.00
Hauling from Winnemucca	1,200.00
Cost of ark, wood scows, etc.	4,900.00
	$8,200.00
Estimated cost of machinery and hull, as above	9,750.00
Bringing cost of outfit to	$17,950.00

The ark and wood scows are 9 feet x 36 feet x 2 feet.

Force required:

One engineer, 1 fireman, 2 deck hands and 1 cook.

Together with such woodchoppers, teams and drivers as might be found necessary to supply fuel.

Fuel, 2 to 3 cords of wood per day, according to quality—sagebrush could be used.

The surveys were conducted by Mr. Parker, mostly in the winter, when the swamp was frozen over. The tules, flags, etc., are frequently 12 to 14 feet high, so that a mowing machine or drags drawn by horses were used to clear the lines. The surveys occupied 200 days, and cost about $1700, and were completed in the spring of 1902.

The dredger hull and barges were about $2\frac{1}{2}$ months in constructing, and were completed and ready to operate by the middle of April, 1902, and cost practically as estimated.

During the spring and summer of 1902 a little over a month's dredging was done, when the operations were stopped by low water and to complete surveys. Work was resumed in November, 1902, and has progressed regularly to date, with the exception of about 5 months of severe freezing weather.

The canal has been constructed from the lower end of the swamp to the upper part of the gorge, a distance of 7.6 miles.

RESULTS, COST, ETC.

These are best measured by the work of 1903. During that year the total working time was 199½ days of 10 hours.

Canal excavated 24,700 feet, or 222,000 cubic yards. Average per day 123.8 feet, or 1100 cubic yards; average per month of 26 days 0.6 mile.

Wood burned, 500 cords	$2,350.00
Labor	2,800.00
Board of employees	800.00
Oil and waste	150.00
Repairs and replacing worn parts	500.00
Total	$6,600.00

Or 27 cents per linear foot of canal; 3 cents per cubic yard.

Charging up one-quarter of the cost of the plant as a sinking fund to one-half of the work, the cost has beeen 4.12 cents per cubic yard. A clam-shell dredge might have given slightly better results in much of this work, but a portion of the bottom material is too hard to be economically handled by this type of machine, which fact ruled in the selection of the dipper dredge.

Fuel in the form of sagebrush or of dwarf juniper was available. The cost of delivery was about the same, but the labor of firing greater in the case of sagebrush—2 cords being about equivalent to 1 of juniper. Juniper wood was hauled 6 to 7 miles and sometimes rehandled; it cost from $4.70 to $3.10 per cord, and has an efficiency greater than pine. The consumption has been at the rate of about 2½ cords per day, or 108 cords per mile of canal; in the peaty subsoil this consumption drops to 70 or 80 cords.

SUMMARY OF RESULTS.

Over ½ or 7.6 miles of canal are completed—25 square miles of the swamp have been drained; 15 square miles of this area are in use, and can be flooded by the use of movable dams in the canal.

The Busse irrigating ditch has been constructed for 10 miles and nearly 6 square miles of arid land brought under irrigation.

The remainder of the canal, about 5.6 miles in length, is being constructed at the rate of over ½ mile per month; and, unless unexpected interruptions occur, will be completed in 12 working months. The West Side irrigation canal will have to be constructed during this period. It will bring under irrigation 6 square miles more of arid sagebrush land.

The necessity of this use of the drained-off water for irrigation has been previously pointed out; a brief recital of the conditions and work done under this requirement will now be made.

The ultimate drainage of the swamp reaches Malheur Lake; around its edges and upon the lower reaches of the river there are reclaimed lands. But, as previously mentioned, the greater portion of the discharge of Blitzen River was naturally taken up by evaporation from the 50 square miles of swamp surface. To drain this quickly down upon pasture and hay lands would provoke suits for damages; hence the irrigation of the sagebrush lands bordering the lower swamp became not only advisable, but obligatory.

The area over which irrigation can be readily extended is about 12 square miles. Nearly one-half of this has been brought under irrigation by the Busse Ditch, on the easterly side of the Blitzen Swamp. This ditch is 10 miles long, and was constructed with plows and drag scrapers. The various sections of a mile each were proportioned to the area to be served by each, as follows:

	Capacity Sec. Ft.	Width at Bottom, Feet.	Depth of Water, Feet.	Grade, Ft. per Mile.	Area to be Served, Rate of 1 Sec. Ft. per 50 Acres.
1	73.5	25.0	3.25	0.75	3,676
2	72.1	25.0	3.0	0.75	3,607
3	68.9	25.0	3.0	0.75	3,446
4	63.8	22.0	3.0	0.75	3,190
5	60.0	20.0	3.0	0.75	3,002
6	48.5	17.0	2.8	1.00	2,424
7	37.9	12.8	2.5	2.00	1,897
8	20.6	6.0	2.0	2.50	1,029
9	7.1	3.0	1.5	3.50	355
10	1.2	ditch constructed with a plow		4.25	62

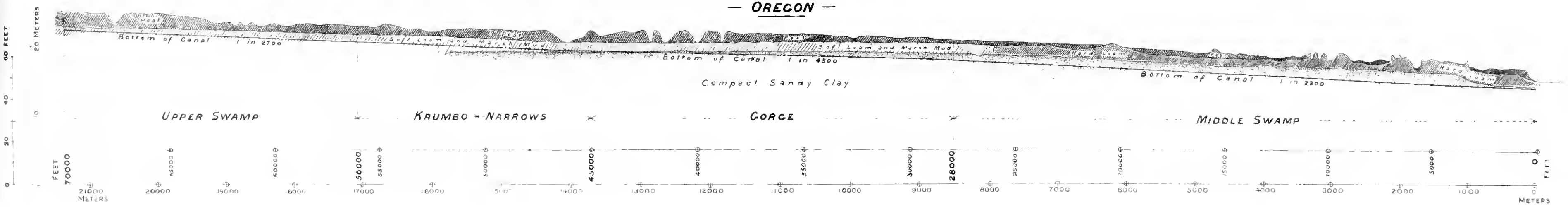
The general character and mode of constructing this ditch are shown in the illustration.

The satisfactory results obtained in this work are largely due to the fact that the work was a unit, entirely in the hands of the engineers. The work was carried out according to a general plan, without the intervention of boards of trustees and self-constituted critics and advisors, and without regard to its political effect. If the far grander problems in the lower reaches of the Sacramento and San Joaquin Rivers and elsewhere could be attacked under the same conditions, equally good results could be obtained.

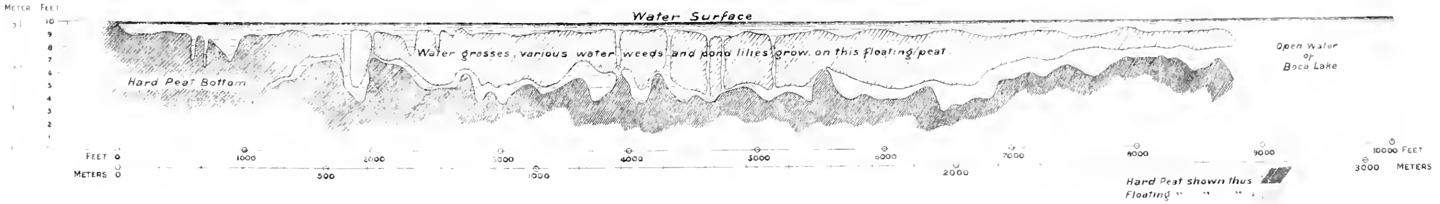
NOTE.—Since the above was written Mr. Parker reports for May:

Days under steam	27	
Days run	26½	
Total distance dredged	6,000	feet.
Dredged per day's run	226	"
Total wood burnt	75	cords.
Wood burnt per day under steam	2.8	"
Wood burnt per 100 feet dredged	1¼	"
Cubic yards moved	41,000	

— PROFILE OF DRAINAGE CANAL —
— BLITZEN SWAMP —
— OREGON —



E-W CROSS SECTION, UPPER SWAMP.
(2000 FT. SOUTH OF STA. 700)
[Section selected to show floating peat]



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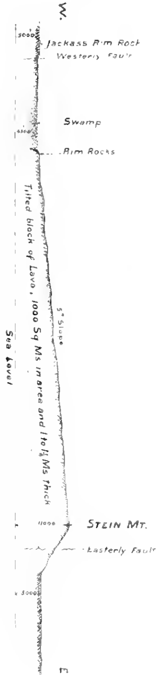
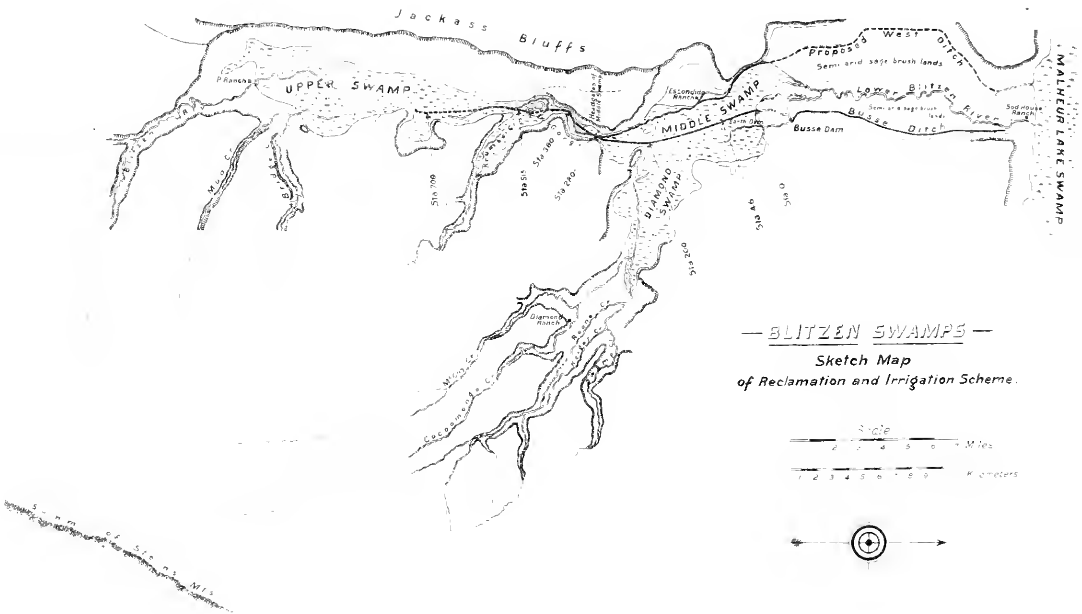


General Section Showing Formation of Blitzen Swamp & Stein Mt.



— Blitzen Swamps —
Sketch Map
of Reclamation and Irrigation Scheme.

Labor and Expenses.

Crew, including cook, etc.	$380.00
Repairs	10.00
Lubricants	25.00
Hauling wood	200.00
Cutting "	113.00
Total	$823.00

Or about 2 cents per cubic yard.

In reply to an inquiry by Mr. Molera, the author would say that the dredger attacked clay, sand and packed gravel with considerable ease. Those strata are shown in the profile that accompanies the work, and the bottom of the canal in places goes down into compact sandy clay, which is not quite so hard as our hard pan, though if the dredger could once get a start under the edge of hard pan it would easily attack it; and that was one of the main conditions that ruled in the selection of a dipper dredge. The clam shell would not economically attack the harder class of material here dealt with.

PIPES AND JOINTS FOR HIGH PRESSURES.

By Franklin Riffle, Member of the Technical Society of the Pacific Coast.

[Read before the Spring Meeting of the Society, May 27, 1904.*]

The tendency of the times is to use higher pressures for the transmission of water, steam and gas, thereby reducing unit costs. On the Pacific Coast conditions are exceptionally favorable for utilizing water under high heads, in order to manufacture comparatively cheap power. During the last ten years California engineers have had the good fortune to design and construct a number of high-pressure plants, and incidentally to contribute much valuable experimental knowledge to the science of hydraulic engineering.

The subject is of vital concern to the engineer, for upon him devolves the responsibility of selecting, with intelligent discrimination, the class of pipe and design of joint that are best adapted to meet the conditions confronting him—having due regard for stability on the one hand and economy on the other. To combine properly these two functions often calls for the exercise of engineering knowledge and skill of the highest order.

The object of this paper is to discuss, as concisely as possible, the several types of pipes and joints that have recently been used for high pressures, with special reference to Pacific Coast practice.

PIPES.

On account of its high tensile strength, combined with other favorable physical properties, such as elasticity, malleability and ductility, steel is peculiarly adapted to withstand the stresses to which pipes are subjected when under pressure. Steel pipe, therefore, has been almost universally adopted for high-pressure work. While many engineers prefer cast-iron pipe for low pressures, on account of its extreme thickness and consequent long life, it is manifestly not adapted to higher pressures. No amount of care in the manufacture, inspection and testing can be relied upon to prevent pipes that are inherently defective from being accepted and used. Such pipes have been known to pass a rigid inspection, including a high hydrostatic test, only to crack in the most mysterious manner when subjected to a low working pressure. This is why steam engineers have discarded cast-iron pipe, and why hydraulic engineers, when dealing with pressures in excess of those ordinarily used in munici-

* Manuscript received June 30, 1904.—Secretary, Ass'n of Eng. Socs.

pal water distribution, are inclined to use it with extreme caution. A notable instance of the use of cast-iron pipe for high pressures is in connection with the Colgate plant of the California Gas and Electric Corporation, where the maximum static pressure for 30-inch pipe is 305 pounds per square inch. In view of the general distrust, by hydraulic engineers, of this class of pipe for high pressures, it would be interesting to know to what extent the Colgate experiment has been successful.

STEEL PIPE MAY BE EITHER RIVETED OR LAP-WELDED.

Riveted pipe is distinctively a California type, having been introduced into the State many years ago, when sheets of iron in stock sizes were brought from the East by sailing vessel to San Francisco, where they were cut to various sizes, punched, rolled and nested. In this compact shape sheets of the proper sizes were transported by water, wagon road and trail to the various mining camps in the interior, where they were riveted together. Even after the advent of railroads riveted pipe continued to be used in California, almost to the exclusion of other types, chiefly on account of its relatively low cost. Increased transportation facilities, however, made it possible to have the pipe riveted into long sections in the well-equipped pipe shops of San Francisco, Los Angeles and Sacramento, a practice which prevails at the present time.

Riveted pipe is made into convenient lengths for handling (20 to 30 feet) by riveting together either conical sections or alternately large and small cylindrical sections, 3 to 6 feet long, each of which has a double-riveted longitudinal seam. The double rows of holes for the longitudinal seams and the single rows for the round seams are punched by power machines, and all overlapping edges are bevel-sheared. After the plates are rolled into cylindrical form and riveted, the seams are made tight by means of a pneumatic calking hammer operating against the beveled edges.

Butt joints with either 1 or 2 cover plates (the latter being presumably the stronger) are sometimes used for shells over $\frac{3}{8}$ inch in thickness. Outside cover plates are bevel-sheared and calked on both edges.

The efficiency of riveted joints may vary from 40 per cent. to 65 per cent. for single riveting, and from 55 per cent. to 75 per cent. for double riveting. As the strength of riveted pipe depends upon the shearing resistance of the rivets and the plates, and this, to a very large extent, upon the thoroughness with which the riveting is performed, it is apparent that rigid inspection during the progress

of the work is essential, in order that the highest efficiency may be obtained.

In the manufacture of lap-welded pipe the longitudinal edges of each plate are scarfed, the plate is rolled in bending rolls until one edge overlaps the other, after which the skelp (as it is termed in mill parlance) is heated to the welding point in a welding furnace and then drawn over a mandrel and through a pair of rolls, the pressure of which on the lapping edges welds them firmly together. The welded joint has a much higher efficiency than the riveted joint, and presents the additional advantage of being as smooth as any other portion of the shell. Moreover, lap-welded pipe has no seams corresponding to the circumferential seams of riveted pipe.

Because of its superior welding properties, soft or mild steel is used by pipe manufacturers in preference to high-carbon steel. For screw-joint pipe Bessemer steel is preferred to open-hearth steel, owing to the difficulty of cutting perfect threads when the latter is used. When the ends of the pipe are to be flanged, open-hearth steel is preferred. When neither threading nor flanging is required, steel made by either process will answer equally well.

In high-pressure pipe lines used for water-power development it has been largely the practice in California to use riveted pipe at the upper end of the line, where the pressures are not excessive, and lap-welded pipe at the lower end. Riveted pipe can be made of lighter plates than lap-welded pipe, which requires a minimum thickness of metal (varying with the diameter of pipe), below which the skelp will not retain its cylindrical form when exposed to the heat of the welding furnace. To illustrate: For 24-inch lap-welded pipe the minimum thickness of skelp that can be used is $\frac{5}{16}$ inch, and for 26-inch pipe, $\frac{3}{8}$ inch, although the pressure conditions may be such that $\frac{3}{16}$-inch shell will be amply strong. In the interest of economy, therefore, it may be found advisable in this instance to use riveted pipe; but when the computed thickness of shell is equal to or greater than the minimum thickness for lap-welded pipe, there is rarely anything to be gained by using pipe with riveted seams.

Up to the present time 30 inches (outside diameter) has been the largest lap-welded pipe made, and that only by one mill—the McKeesport Mill of the National Tube Company. But as preparations are now being made to manufacture 36-inch pipe, this size may be considered the maximum for lap-welded pipe. Therefore, whenever the desired volume of water is too large to be conveyed by a 36-inch pipe, it may be necessary to choose between 2 lines of lap-welded pipe and a single line of riveted pipe. The latter plan

is evidently the more economical, although if the pressures are excessive there may be no alternative but to adopt the former, or at best a combination of the two. Thus it is obvious that each class of pipe has its advantages and also its limitations; and while there can be no question concerning the superiority of lap-welded pipe, the element of cost often operates to restrict its use to the highest pressures.

JOINTS.

Lead joints have been employed with excellent results in pipe lines of small diameters conveying water under fairly high pressures. The bell and spigot type of joint has been used under a variety of modified forms for connecting lap-welded pipes, but only two have survived the test of many years of experience. These are the Converse and the Matheson joints.

The *Converse* lock-joint, or coupling, Fig. 1, consists of a heavy cast-iron hub, with internal recesses at each end, which receive two lugs or rivets fastened to each end of each length of pipe. After the pipe enters the hub it is revolved slightly until the joint is "locked."

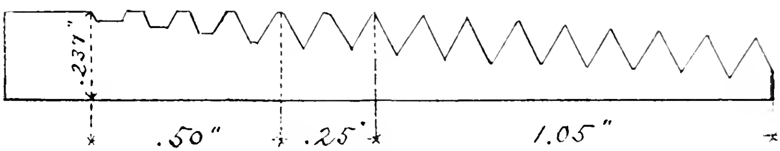


FIG. 1.

In this position it is impossible to pull the pipe out of the hub without first shearing off the rivets. The annular space between the pipe and the hub is then poured with lead and calked in the usual way.

The *Matheson* joint is formed by expanding one end of each length of pipe sufficiently to form a bell or socket, which is reinforced at the extreme end by shrinking on a steel band. A groove is cut around the outside of the spigot end, to resist the tendency of the lead packing to slip when the joint is under pressure.

Of the two forms of lead joint described the Converse is much the stronger, and therefore better adapted to high pressures. When reasonable care and skill are used in laying Converse pipe, the joints can be relied upon to stand much higher pressures than are commonly considered safe for lead joints. In the summer of 1901 a pipe line was laid by the Pacific Improvement Company near Santa Barbara, consisting of 10,000 feet 7-inch No. 9 gauge, 10,000 feet 8-inch No. 8 gauge and 13,500 feet 8-inch No. 6 gauge, all Con-

verse joint steel pipe. This line terminates in two branch lines, each leading to a reservoir. At the end of each branch is a gate valve. As the total head is 1370 feet, it was not intended that both gates should ever be closed at the same time. However, after the line had been in operation for some time, an employe carelessly closed one of the gates without first opening the other, with the result that the entire line was subjected to a static pressure that amounted at the lower end to 590 pounds per square inch. A careful inspection of the line soon after failed to disclose a single leak. Another example, the 8-inch force main of the Prescott (Arizona) Waterworks, where several miles of Converse steel pipe 0.14 inch thick are being operated under a maximum working pressure of 420 pounds per square inch, is a forcible illustration of the efficiency of a properly designed and well-made lead joint, even for high pressures.

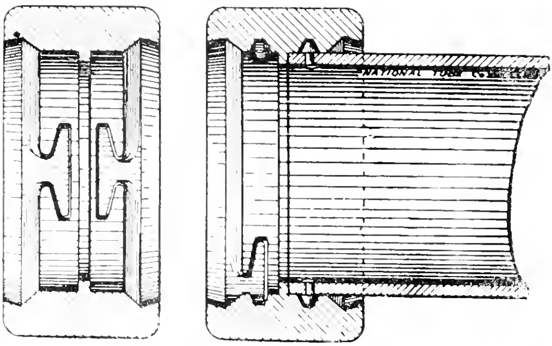


FIG. 2.

These examples have been cited to show that although lead joints for high pressures are not generally regarded with favor by hydraulic engineers, they are nevertheless worthy of some consideration. They have the merit of being economical in first cost and of being easily and readily repaired in case of leakage. Generally speaking, however, the working limit for lead joints should not exceed 300 pounds pressure per square inch.

Screw joints are formed by means of sockets or couplings, into which are screwed the threaded ends of the pipes. Couplings for standard pipe have straight threads, while the pipe threads have a taper of $\frac{3}{4}$ inch to 1 foot. After screwing together a number of standard pipes, it will be found that at nearly every joint a portion of each pipe thread remains exposed outside the socket. These are the weak portions of the pipe, and there is always danger of breakage at the bottom of an exposed thread from bending stresses which cannot always be avoided in laying a line of pipe. This danger,

however, is minimized by the practice of cutting vanishing threads on the pipe. Fig. 2 shows a section through the threaded end of a 4-inch standard pipe. The threads have a pitch of $\frac{1}{8}$ inch (8 threads per inch), and their total length is $1\frac{8}{10}$ inches. Starting at the end of the pipe there are 8 perfect V-threads, then 2 threads that are perfect at the bottom and slightly flattened on top, and finally 4 imperfect threads, the last one being but little more than a scratch.

The *line* pipe coupling (Fig. 3) is a modified form of the standard pipe coupling, from which it differs in the following important details:

1. It is longer and heavier.

2. The ends are recessed, in order that they may fit the pipe snugly just outside the thread, which is thereby fully protected from any bending stresses that may come upon the pipe.

3. The threads have a taper of $\frac{3}{4}$ inch to 1 foot, to correspond to the taper of the thread of the pipe. This insures a perfect contact for every thread—a prime essential for tight joints.

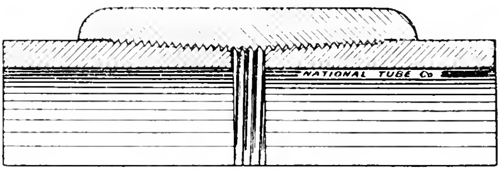


FIG. 3.

A leaky line pipe joint indicates imperfect or damaged threads or carelessness in connecting the pipes. To avoid damage from transportation, it is the practice of the best mills to screw a heavy guard or protector (usually a half coupling) on the exposed thread of each length of pipe.

In California, line pipe is largely used to convey oil under pressure. A considerable number of 2-inch, 3-inch and 4-inch lines are in operation in the several oil fields of the State, and some of them are subjected to very high working pressures. (The Standard Oil Company's 8-inch line will be referred to later.)

Line pipe is also used in California for the transmission of gas under high pressures. In many localities it is more economical to supply two or more towns from one source, through small pipes at high pressures, than to construct and operate a generating plant in each town.

In one of the first attempts at high-pressure gas transmission in this State 2-inch standard pipe was used, but after the completion of the line the joints leaked so badly at a pressure of 15 pounds

per square inch that it became necessary to take up the pipe and relay it after replacing the couplings with line pipe couplings. In contrast with this unfortunate experience may be mentioned another similar undertaking—a 9-mile line, consisting of 2-inch and $2\frac{1}{2}$-inch line pipe. The line was tested at frequent intervals during the progress of the work, and in one instance, when a leaky joint was detected, all the pipes were taken up and relaid as far back as the leak. Upon the completion of the first 5 miles of the line it was tested to 100 pounds air pressure, for a period of 36 hours, without developing the slightest leak. These two examples show the superiority of line pipe couplings and the advisability of using them in preference to standard couplings for high pressures.

Riveted joints are frequently used in pipe lines whose diameters are not less than 20 inches, inside measurement, this being the smallest pipe in which even an undersized riveting helper can work to advantage. The maximum head for which this type of joint

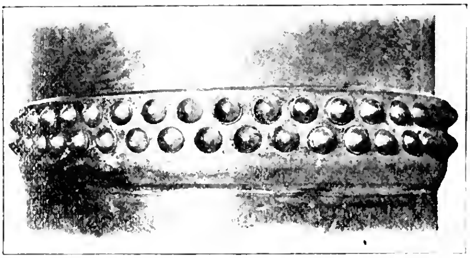


Fig. 4. Expanded Joint with two Rows of Rivets.

should be used is about 1200 feet, although it has been used for even higher heads. In laying riveted pipe, the lengths are riveted together after the manner of connecting the short sections in the shop, each length having a large and small end. Field riveting and calking are sometimes done by hand and sometimes by compressed air. Riveted joints are also used for lap-welded pipes. They are then termed "bump" or "expanded" joints, because one end of each pipe is upset or expanded. The expanded end is beveled for calking. Ordinarily the joints are single riveted, but when very high heads are used, requiring heavy pipe, it has been found necessary to resort to double riveting in order to make the joints tight. (Fig. 4.)

Flange joints are more expensive than the preceding types, hence their use in hydraulic work is generally confined to extraordinary pressures. The flanges are usually faced in a lathe, but this alone will not prevent leakage. The faces may be ground together until they fit so perfectly that the joint will be tight, but this

operation is very costly; hence the well-known expedient of using a filler or gasket of some pliable material—usually copper for steam pressure and rubber for hydraulic pressure. In a properly designed flange joint a small gasket may be made quite as effective as a large one, and there is no reason why it should extend outside the bolt circle.

With reference to the manner in which they are attached to the pipes, flanges may be classified as *screwed*, *riveted* and *welded*.

Screwed flanges of cast iron or cast steel, although largely used for steam, are rarely used for extreme hydraulic pressures, except for pipes of very small diameter. It is the practice of the Crane Company, of Chicago, in their steam-fitting business, to screw the pipe into the flanges until the ends project about $\frac{1}{16}$ inch. By means of a special lathe the projecting ends are then cut off and a light cut taken off the face of each flange to make it normal to the axis of the pipe. To prevent leakage the threads of the flanges and of the pipe should have the same taper.

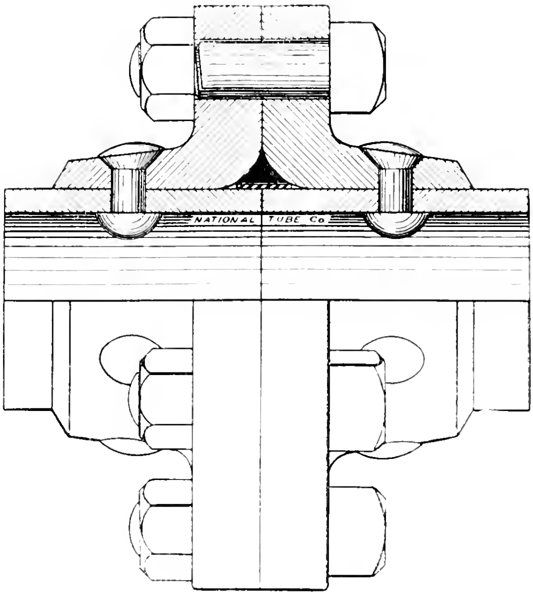


FIG. 5.

Riveted flanges (flanges riveted to the pipe) may be of cast iron, cast steel or pressed steel. They may be faced and bolted together with a gasket between (Fig. 5), or they may be riveted together as in Fig. 6, in which case they are made of pressed steel, without facing or gasket, the joints being made tight by calking the

beveled edges of the flanges. It is an excellent practice to shrink the flanges on the pipe before riveting them.

Welded flanges of forged steel form an ideal joint for high pressures. The method of welding employed by the National Tube Company consists of slipping a rough-forged steel flange over the end of the pipe, then heating both pipe and flange to the welding point, after which they are withdrawn from the forge, the flange

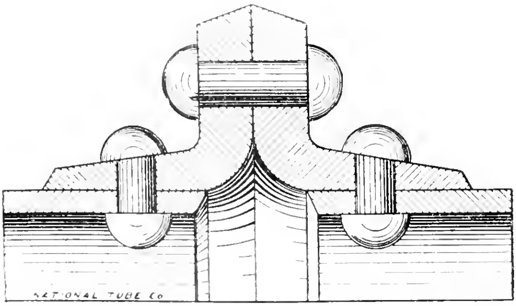


FIG. 6.

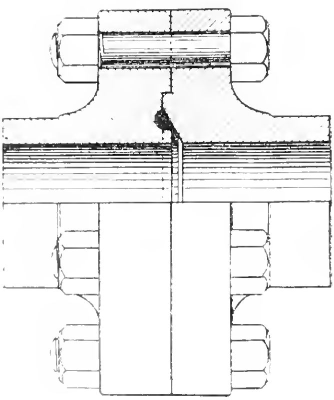


FIG. 7.

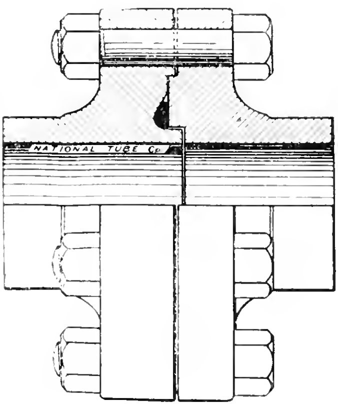


FIG. 8.

placed on an anvil and slowly revolved, while the rapid blows of a steam hammer directed against the inside of the pipe solidly weld flange and pipe together.

In Europe the welding is performed by means of the electric arc. The flange is first beveled on its inside edge, so that when it is fitted on the end of the pipe a V-shaped space is left, into which small pieces of steel are laid. These, together with the contiguous metal of both pipe and flange, are heated to a welding temperature

by the electric arc, the welding being performed by a pneumatic hammer. This operation welds the flange only about three-fourths through its thickness. The remaining fourth at the extreme end of the V-shaped filling is then burnt out next to the pipe by means of the electric arc, and filled, heated and welded in the same manner as the back of the flange.

The writer is informed that the Union Iron Works of San Francisco have a plant for welding flanges to steam pipes, but is not advised concerning the method employed.

As the solid welded flange joint is used for extremely high pressures, it is very important that the annular groove or recess in the face of one of each pair of flanges be so designed that when the flanges are bolted together the gasket cannot be forced out of its position in the groove by the pressure inside the pipe. The joint designed by Mr. W. R. Eckart for the Standard Electric Company

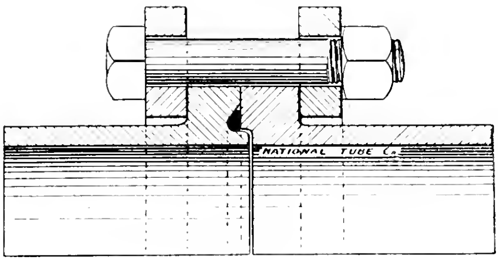


FIG. 9.

(Fig. 7) and the one designed by the National Tube Company (Fig. 8) are both in use in important pipe lines in California, and are giving excellent satisfaction. The distinctive feature of these joints is the annular groove, into which is compressed a circular rubber gasket when the flanges are drawn together. No matter how great the pressure, the gasket cannot be blown out, since the tendency is to squeeze it more tightly into the groove.

A modified form of the welded flange consists of a heavy band or ring, welded on the outside of the pipe at each end, faced and grooved in the same manner as the flanges just described. The faces are drawn together by means of bolts through a pair of loose flanges behind the rings. (Fig. 9.) This style of joint was adopted for the 5-inch pipe line at Simplon tunnel (Switzerland), operating under a maximum pressure of 2250 pounds per square inch. A similar joint is used in a power line near Vouvry, Switzerland, under a head of 3117 feet.

A FEW REPRESENTATIVE PIPE LINES ON THE PACIFIC COAST.

The following brief description of a few representative pipe lines is designed to illustrate the conditions under which hydraulic engineers have deemed it expedient to use the several types of pipes and joints referred to in this paper.

The San Joaquin Electric Company's pipe line (near Fresno) has the distinction of being the pioneer high-pressure power line of the Pacific Coast. It was constructed in 1896. Its length is 4020 feet and its total head is 1406 feet. There are 960 feet 24-inch riveted pipe No. 12 gauge steel, 860 feet 24-inch riveted $\frac{1}{4}$-inch steel, 400 feet 20-inch lap-welded $\frac{5}{16}$-inch steel with Converse joints, 800 feet 20-inch lap-welded $\frac{5}{16}$-inch steel with flange joints, and 1000 feet 20-inch lap-welded $\frac{3}{8}$-inch steel with flange joints. The flanges were shrunk on and riveted to the pipes, one of each pair being recessed, while the other has a corresponding annular projection. Each joint contains 16 bolts 1 inch in diameter. A rubber gasket was used between the faces.

During the year 1900 the Standard Electric Company constructed two parallel pipe lines for power development, each consisting of 2813 feet 48-inch wooden stave pipe, 464 feet 48-inch riveted pipe $\frac{5}{16}$-inch steel, 760 feet 30-inch cast-iron pipe with shells 1 inch, $1\frac{1}{4}$ inches and $1\frac{1}{2}$ inches thick, corresponding to 275 feet, 550 feet and 700 feet static heads, respectively, and 2365 feet 30-inch lap-welded steel pipe with shells $\frac{7}{16}$ inch, $\frac{1}{2}$ inch, $\frac{5}{8}$ inch and $\frac{3}{4}$ inch thick, depending upon the static head. The total head is 1475 feet. The joints for all of the lap-welded pipe are of the solid welded flange type. (Fig. 7.) The flanges are $2\frac{1}{4}$ inches thick. Each joint contains 32 bolts, 1 inch, $1\frac{1}{8}$ inches and $1\frac{1}{4}$ inches, the size depending on the pressure.

The Keswick pipe line of the Northern California Power Company, constructed in 1901, is 6800 feet long, and has a maximum head of 1204 feet. It consists of 800 feet 42-inch wooden stave pipe, 3600 feet 30-inch riveted No. 8 gauge to $\frac{3}{8}$-inch steel, and 2400 feet 30-inch lap-welded $\frac{7}{16}$-inch to $\frac{5}{8}$-inch steel. The lap-welded pipe has expanded joints, with 1 row of rivets for the $\frac{7}{16}$-inch and $\frac{1}{2}$-inch steel and 2 rows for the $\frac{5}{8}$-inch.

The Colgate plant of the California Gas and Electric Corporation has 5 lines of 30-inch pipe, each of which is 1625 feet long, the maximum head being 702 feet. The upper portion (680 feet) consists of riveted pipe, No. 12, No. 10 and No. 8 gauge steel, while the lower portion (945 feet) consists of cast-iron, with shells varying

in thickness from 1 inch to 1½ inches. The cast-iron pipes are 12 feet long, the joints being of the usual bell and spigot type, filled with lead and calked in the usual way. The pipes are firmly anchored to bed rock by massive concrete piers.

The De Sabla plant of the California Gas and Electric Corporation, near the town of Chico, contains 2 parallel lines of 30-inch pipe (the first completed last year and the second now in process of construction), each 6225 feet long, consisting of 5200 feet of riveted No. 10 gauge to $\frac{9}{16}$-inch steel (maximum head approximately 1100 feet), 465 feet lap-welded ½-inch, $\frac{9}{16}$-inch and ⅝-inch steel with expanded joints (maximum head about 1300 feet), and 560 feet lap-welded $\frac{11}{16}$-inch and ¾-inch steel with solid welded flange joints. The total head is about 1500 feet.

The pipe line of the Mill Creek No. 3 plant of the Edison Electric Company, near the town of Redlands, is 8400 feet long from the forebay to the power house. There are 2485 feet 26-inch and 2150 feet 24-inch riveted steel No. 14 to No. 0000 gauge, 2830 feet 24-inch lap-welded ⅜-inch to ¾-inch steel with expanded joints, and 620 feet 24-inch lap-welded ¾-inch steel with solid welded flange joints. (Fig. 8.) Near the power house the line divides into two 18-inch lap-welded ⅝-inch steel branches, and each of these into two 14-inch lap-welded ½-inch steel branches, all with solid welded flange joints. The total head is 1960 feet. The steel for the lap-welded pipe is basic open hearth, ultimate tensile strength 50,000 to 60,000 pounds per square inch, and the pipes were tested at the mill to 1½ times the static pressures indicated by the profile.

The Standard Oil Company's pipe line, extending from the Bakersfield and Coalinga oil fields to Point Richmond on San Francisco Bay, a distance of 278 miles, was completed in 1903, and is used as a pumping main for the transportation of oil. It consists of 8-inch standard line pipe of soft open-hearth steel, ultimate tensile strength from 40,000 to 50,000 pounds per square inch. Each pipe was subjected at the mill to a hydrostatic test of 1500 pounds per square inch. The working pressure is approximately 600 pounds per square inch.

The Columbia Improvement Company have recently completed, near Tacoma, Wash., 4 lines of riveted steel pipe, each 1700 feet in length, and with a total head of 900 feet. Each line is made up of 450 feet 48-inch lap-riveted ¼-inch and $\frac{5}{16}$-inch steel, 200 feet 45-inch butt-strapped ⅜-inch steel, 400 feet 42-inch butt-strapped ½-inch steel, 400 feet 40-inch butt-strapped ⅝-inch steel, and 250 feet 36-inch butt-strapped ¾-inch steel.

Although the foregoing brief description is far from being complete, it will serve to give a general idea of high-pressure practice on the Pacific Coast, which has been one of the objects of this paper.

The writer is indebted to Mr. T. W. Brooks, of the National Tube Company, for illustrations of high-pressure joints, and to Mr. G. R. Field, of the Risdon Iron Works, for information concerning the pipe lines of the Columbia Improvement Company.

VERTICAL RAILWAY CURVES.

By H. I. Randall, Member of the Technical Society of the Pacific Coast.

[Read before the Spring Meeting of the Society, May 27, 1904.*]

Vertical curves in railroad work, to round off the angle made by the change in grade rate, have undoubtedly been used for many years and probably since railroads were first built; but the writer is, from personal observation, constrained to believe that many have not given some phases of the subject the careful consideration which they deserve, *e. g.*, just why they are needed and how long they should be. The practice seems to be to put in a curve generally 200 to 400 feet or more in length without any definite or adequate theoretical basis for the same. The writer proposes to consider what justification there is for this practice and to show that the advantage of increasing the length of the vertical curve is much greater with short trains than with long ones, and that it is a great advantage to have the locomotive exert as great a pull as practicable in passing sags in the grade line; in fact, that to have the locomotive exert a great pull is, at least theoretically, the most effective way to have a train pass a sag in the grade line without the cars crowding together and thereby causing a shock or jerk.

Vertical curves do or may serve a double function.

Case I.—They enable the train to pass from one grade to another without the shock which would occur with too sudden a change of the movement of the parts (as single cars) of the train in a vertical plane.

Case II.—They may keep the couplings from changing from tension to compression, and in so doing avoid a jerky movement of the train which may become so great as to break the train in two.

The following notation will be used:

L = the weight of the locomotive, in tons of 2000 pounds.

C = the average weight of 1 car and its load, in tons of 2000 pounds.

α = the pull in pounds which the locomotive is exerting for each ton of its weight.

β = the change in grade rate on the vertical curve in 1 car length. The locomotive is considered to be of the same length as a car. The length of a car, at any point on a vertical curve, and its horizontal projection are assumed to be the same; or β is assumed to be constant.

* Manuscript received June 30, 1904.—Secretary, Ass'n of Eng. Socs.

Q = the pull in pounds the locomotive must exert to keep compression from a coupling or from several couplings.

R and r = grade rates at the ends of the vertical curve.

n = the total number of cars in the train.

a = the number of car lengths the vertical curve is long.

d = the number of cars at the rear end of the train off the vertical curve.

m = the number of cars at the forward end of the train which have passed off the curve.

For Case I, suppose the locomotive (or a car), Fig. 1, in passing from the left toward the right has moved so the forward truck is at A, the end of the vertical curve AB. As it continues to move, it will rotate about the rear truck in a vertical plane, or suddenly be given an angular acceleration about that point. The magnitude of this acceleration depends upon the velocity at which the car is moving, the length of the car and the length of the vertical curve. For an abrupt and considerable change of grade rates and with a verti-

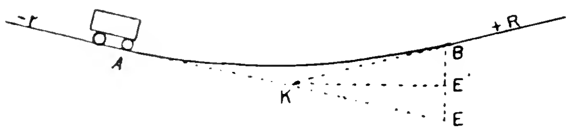


FIG. 1.

cal curve of zero length or practically so, and a high velocity, an objectionable shock would undoubtedly occur due to this acceleration. For short vertical curves and considerable change in grade rates this acceleration is not likely to be objectionable.

Assume a vertical curve, AB, joining the grades — r and + R as 100 feet long on a straight track and the change in grade rate to be 2. Draw through K, the intersection of the grades, a horizontal line intersecting the vertical through B at E′. Produce BE′ to intersect the grade — r produced at E. Then KE′ = 50 feet and BE = 1 foot. A circle tangent to the grades — r and + R at A and B respectively would be essentially coincident with the flat parabolic vertical curve AB, and BE would be essentially the tangent offset from AK for this circle in 100 feet. A circle 100 feet long and with a tangent offset of 1 foot corresponds to a 1° 09′ curve. The pressure would, of course, be normal or vertical to the track.

A horizontal curve of this degree, if the pressure is normal to the track, would be considered a very easy curve, and would give no objectionable shock due to the movement of one end of the car about the other end as the car passes on the curve; so in this case

a light curve would be less objectionable even with high speed. From this point of view very short curves satisfy all practical requirements.

Deductions could easily be made showing what this angular acceleration and the pressure would be, but even if made they would not indicate whether a certain curve were objectionable or not.

The vertical curve might be so short that the axes of adjacent cars would make so large an angle with one another that a pair of couplings that were together would slip on one another and cause them to part; but with the shortest curve which could reasonably be used on a railroad this would hardly occur.

For Case II as a preliminary to a more detailed study as to why they are needed for this purpose, a careful consideration of the movement of a train over a grade under different conditions is desirable.

As is well known, the grade of repose for a railroad train is, for any given velocity, that grade down which a descending train

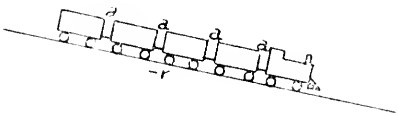


FIG. 2.

will roll indefinitely without increasing or decreasing its velocity. The grade of repose quite rapidly increases as the velocity increases if the velocity is greater than about 8 miles per hour. Also the grade of repose for the locomotive, loaded and unloaded freight cars and passenger cars is somewhat different, but as matters are simplified by assuming that it is the same for all parts of any train, and as it seems impracticable to consider it otherwise for our purposes, and as it leads to no material error, we will so consider it.

When a train moves over a track its movement is affected by the value of the grade of repose and by the actual grade. The effect of the grade of repose on its movement is the same whatever the actual grade on which the train happens to be. It is the same for all parts of the train (with the assumption above) and simply changes with the velocity. The effect of the actual grade on the velocity is definite and can be easily calculated.

Suppose the locomotive and a train of cars, Fig. 2, are running down a grade, — r, and that the locomotive is *not* working. If the rolling resistance is the same per ton for the locomotive and cars, evidently there will be no tension in the couplings, a, a. The veloc-

ity of the train will be affected by the grade of repose and the actual grade.

If r is less than the grade of repose for the moving train, the train will be decreasing in velocity, but without making the couplings, a, a, tension or compression. As the grade of repose is less for low than for high velocities, it is entirely possible for the velocity, if high, to decrease until the grade of repose for the decreased velocity becomes equal to r, when the train will continue indefinitely at that velocity or until r changes. If the grade of repose of the moving train when at its least value is greater than r, then the train will decrease in velocity until it stops. If r is greater than the grade of repose for the moving train, the velocity of the train as a whole will increase until the grade of repose has risen to r, when the velocity will remain constant, or r changes.

If the locomotive *is at work* while running down the grade, all the couplings will be in tension, the one immediately back of the locomotive will have the greatest tension, and they will gradually decrease until the one in front of the rear car is reached, where the

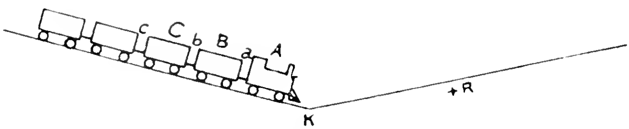


Fig. 3.

tension will be the least. As far as velocity is concerned, the effect of the locomotive working in running over any grade is just the same as though r were increased if r is a minus or a down grade, and decreased if r is a plus or an up grade. The amount of this increase or decrease is practically 1 foot for each 20 pounds tractive force the locomotive exerts on each ton of the train including the locomotive. This is true because the accelerating force due to gravity on the grade r is almost exactly 20 r pounds per ton (2000 pounds) of train. On a uniform grade of indefinite length, the velocity would decrease to zero or change until the r as in effect changed by the constant force exerted by the locomotive became equal to the grade of repose, when the velocity would remain constant.

Now let us advance a step and see what takes place when the train passes from one grade to another, as shown in Fig. 3. Suppose the train is moving down grade — r at a uniform velocity and that the locomotive is *not* working. There would be neither tension nor compression in the couplings, a, b, etc. The moment the locomo-

tive reaches the grade R or passes K it would begin to decrease in velocity, and the couplings, a, b, c, etc., would become compression. Assuming that the velocity is such that the whole train will pass K, and that R is a plus or up grade, it would be only a question of a short time when the train would be brought to a stop, and in doing so the couplings would become compression, but with a shock. If r is great enough the train would roll back, but with no shock, as the locomotive and cars would stop and begin the backward movement at the same time; and if the grade of repose was the same for the locomotive and cars, the couplings would, after yielding the compression of their springs, be neither in tension nor compression. In practice, probably, they would change locally from compression to tension, but that only slowly.

If the locomotive is working when it reaches K, the results would be different. There would be tension in a, b, c, etc. When the locomotive has passed K, whether there is tension in the couplings or not depends upon how much the locomotive is working.

In order to have the locomotive, when entirely on grade R, move at the same velocity as the cars B, C, etc., entirely on grade r, the force exerted by the locomotive, upon itself in this case, must evidently be 20 (R — r) L pounds at least. The locomotive would be doing work at the rate of 20 (R — r) Lv foot-pounds per second if v is the velocity in feet per second. While the locomotive is passing K, if it is to have the same velocity as the cars the force exerted by the locomotive must be at least something between 20 (R — r) L and zero. The exact amount at any instant depends upon just how much of the locomotive has passed K. If the locomotive was exerting a force of just 20 (R — r) L when it had just passed K, there would be no tension in any of the couplings. If the locomotive is exerting a force less than this amount, the car B will crowd on the locomotive, and a moment later the car C would crowd up and the couplings would change from tension to compression, one at a time. Of course, this action is only momentary, for as soon as B passes K the conditions have changed. If when the locomotive has just passed K it is exerting a force greater than 20 (R — r) L, all the couplings, a, b, c, etc., would be in tension.

Now, assume the car B has just passed K and that the locomotive and the car B are on grade R while the rest of the train is on grade r. If the locomotive, A, and the car, B, are to move at the same velocity as the remainder of the train, the locomotive must evidently exert a force of at least 20 (R — r) (L + C). If the force exerted by the locomotive is less than this, the car C will first crowd on B, and the coupling, b, will become compression. The

cars C, D, etc., would soon crowd ahead if the conditions were not changed by the movement of the train. If the force exerted by the locomotive was greater than 20 (R — r) (L + C), all the couplings would be in tension, but decreasing in amount in passing from the head to the rear of the train.

If Q is the force the locomotive must exert to keep compression from all the couplings when the locomotive and n cars are on the grade R, then Q = 20 (R — r) (L + nC). With the locomotive exerting a force greater than this, the movement of the train as a whole, as regards change in velocity while on grades r and R, is exactly the same as though the whole train were on r, as before explained, and the locomotive was exerting a force equal to the actual force less Q. If the force exerted by the locomotive is sufficient to haul the train up the grade R, but is so small that all or part of the couplings become compression, and the whole train has passed K, then there is a time when the rear cars will have de-

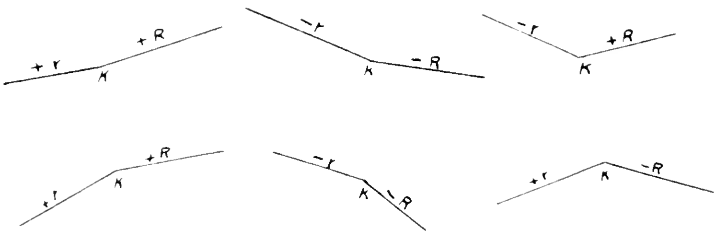


Fig. 4.

creased in velocity, so that momentarily the different parts of the train will be moving at different velocities, the front faster than the rear. This will cause the couplings to change from compression to tension. First one coupling near the front end will change as the locomotive pulls out, and an instant later the next to the rear of this. As each change takes place there is a jerk. This jerk becomes greater as each succeeding coupling changes from compression to tension, and may become so great as to break the train in two. To assist in avoiding this action is at least one of the purposes of the vertical curve.

If the locomotive is always working sufficiently to keep all couplings in tension when passing a sag in the grade line, just what the grade of repose happens to be for the particular velocity of the train is not material, as in this case the locomotive overcomes the effect due to change in grade rate. When the locomotive is not working sufficiently to gain this end, the movement of the rear end of the train is affected by the grade of repose and the actual grade,

while the front end is affected by the grade of repose, the actual grade and the pull of the locomotive. The resultant effect will be for the rear part of the train to crowd upon the forward part.

In order to have the above formulæ general, notice grades R and r must be used with the proper signs. When R and r have such signs that (R — r) is plus, the locomotive must exert a force to pull the train ahead to keep compression from the couplings. When (R — r) is minus, the locomotive need not work to keep the compression from the couplings, for then the forward part of the train will tend to move faster than the rear part on passing the point where the grade rate changes. Grades like Fig. 4a give (R — r) plus, while grades like Fig. 4b give (R — r) minus.

There would be no change from tension to compression in the couplings in passing K when (R — r) is negative, whether the locomotive is working or not. Therefore, theoretically, it is not essential to use a vertical curve to keep the couplings from changing

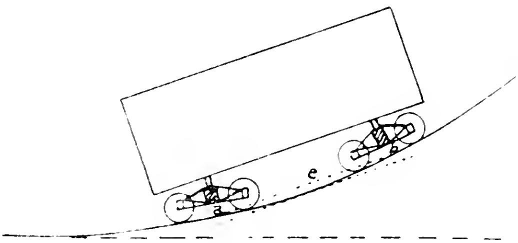


FIG. 5.

from plus to minus in passing such a place. While theory does not require one, it is, nevertheless, common practice to put one in whether (R — r) is plus or minus, and properly so, in order not to have the change in the amount of tension in the couplings so sudden as to cause a jerk. The case where (R — r) is minus will not be further considered.

By a line of reasoning similar to the above and more extended, a determination can be made of the proper length of the vertical curve, or the allowable change in grade rate per station, based on the condition that the cars shall never crowd upon one another.

Assume the vertical curve to be a parabola, which is in conformity with the usual practice. The front and rear trucks of any car on the curve will be on different grades. At any instant each car and the locomotive will have a double movement: first, one of rotation in a vertical plane, and second, one of translation in the direction of the line joining points below the two pairs of trucks, as more definitely defined below, for the cars or similar points for the locomotive.

The first motion is that considered in Case I. For the second, the movement of any car will be essentially the same as though both trucks of that car, Fig. 5, were on a grade equal to the grade of the tangent to the parabola under the middle, e, of a line, ab, extending from center to center of the wheel bases of the trucks of the car or similar points for the locomotive. At this point the grade rate of the tangent to the parabola is the mean of the grade rates of the tangents to the parabola under the centers of the two trucks, or at the points a and b. So it will be assumed that the grade on which any car or the locomotive is moving is the grade under the middle point of the line, defined above, joining the wheel bases, and the problem becomes one of considering the action of the train in passing from grade r over a series of grades, the vertical curve, to the grade R. Each grade would be one car-length long, and of a rate which is that under the middle of the particular car.

Consider, first, the case where the train is *so short that the whole of it can be on the vertical curve at the same time.* Let the train approach the curve from the left, Fig. 6, and assume that the locomotive and h cars are just on the curve, or the coupling, e, is just over P. Then due to the action of the grades under the respective cars and the locomotive, all the cars to the left of P will move at the same velocity; E will move slower than F, D slower than E, C slower than D, etc. The grade rate under the car E will be $- r + \frac{\beta}{2}$. The force, $\underset{\sim}{Q}$, necessary to be acting on E to keep its velocity the same as F, and therefore compression from e, is

$$20 \left[\left(- r + \frac{\beta}{2} \right) - (- r) \right] C = 20 \frac{\beta}{2} C.$$

This is really the force that must act along the axis of the car, but this force is practically equal to $\underset{\sim}{Q}$ in each case, and is so assumed. The grade rate under D is $- r + \frac{3}{2} \beta$, so at the same time the $\underset{\sim}{Q}$ to act on D to keep compression from d and e is $20 \frac{3}{2} \beta C$, and similarly for each successive car to the right. $\underset{\sim}{Q}$ for the locomotive will be $20 \frac{2h + 1}{2} \beta L$. From this it is easily seen that $\underset{\sim}{Q}$ for the whole train will increase as the train moves to the right until at least all but one car has passed the point P as in Fig. 7. When in this position, $\underset{\sim}{Q}$ for F would be $\frac{20 \beta}{2} C$; for E, $20 \times \frac{3}{2} \beta C$; for D, $20 \times \frac{5}{2} \beta C$, etc., and for the locomotive $20 \frac{2n - 1}{2} \beta L$.

When G has just passed P, Fig. 8, (also with the whole train at any position on the vertical curve) Q for F, to keep compression from f, is $20\beta C$; for E, to keep compression from f, is $20 \times 2\beta C$, etc.; and for the locomotive, to keep compression from f, is $20\,n\,\beta L$,

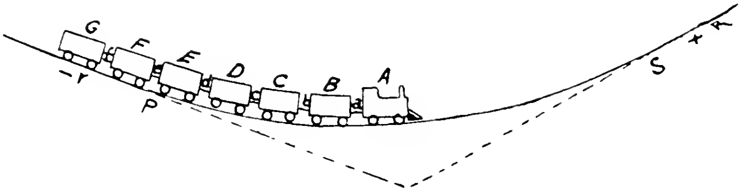


Fig. 6.

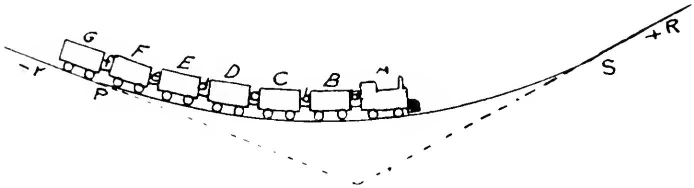


Fig. 7.

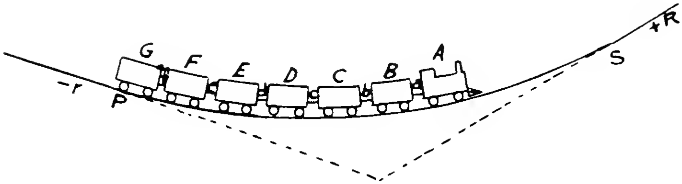


Fig. 8.

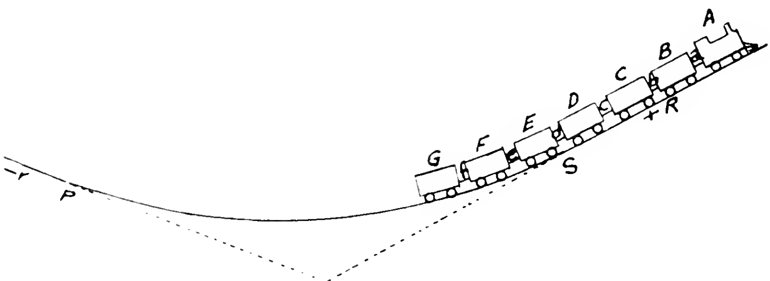


Fig. 9.

or for the locomotive and every car the demand on the locomotive is greater than when the train is in the position shown in Fig. 7. Then for the whole train, when in this position, to keep compression from f,

$$Q = 20\beta\left[\,(1 + 2 + 3 \,.\,.\,.\,.\,.\,.\,. (n - 1)\,)\,C + n\,L\right]$$

$$= 20\beta\left[\frac{n\,(n-1)}{2}\,C + n\,L\right] \qquad (1)$$

If the locomotive and m cars have passed off the vertical curve to the right. Fig. 9, then Q for F, to keep compression from f, is $20\beta C$; and Q for E, to keep compression from f, is $20 \times 2\beta$ C, etc. Q for each car to the right of S is $20\,(n - m - \frac{1}{2})\,\beta$ C and Q for the locomotive is $20\,(n - m - \frac{1}{2})\,\beta$ L. Then for the whole train, when in this position, to keep compression from f,

$$Q = 20\beta\Big[(1 + 2 + 3 \,.\,.\,.\,. (n - m - 1)\,)\,C + \Big(n - m - \frac{1}{2}\Big)\,(m\,C + L)\Big]$$

and hence

$$Q = 20\beta\left[\frac{(n-m)\,(n-m-1)}{2}\,C + (n - m - \frac{1}{2})(m\,C + L)\right] \quad (2)$$

By multiplying out,

$$Q = 20\beta\left(\frac{1}{2}\left[n\,(n-1) - m^2\right]C + (n - m - \frac{1}{2})\,L\right) \quad (3)$$

In this equation, notice the coupling, f, must be on the curve or $m \leqq (n - 1)$. When $m = n$ the coupling, f, has passed off the curve and the equation does not hold.

From equation (3) it is easily seen that as m increases, Q, or the demand on the locomotive, decreases. When the last car has passed off the curve, the locomotive need exert no pull to keep compression from the couplings.

When the train is of such length that the whole of it can be on the vertical curve at one time, by comparing equations (1) and (3), in which m equals zero, it is seen that the greatest demand on the locomotive occurs when the train is entirely on the vertical curve. It is also easily seen that the demand on the locomotive to keep compression from all the couplings, when the whole train is in any position on the vertical curve, is that given in equation (1). Therefore the exact position of the train on the curve is immaterial.

In equation (1), solve for β after making $Q = \alpha$ L, and get

$$\beta = \frac{\alpha\,L}{20\left[\frac{n\,(n-1)}{2}\,C + n\,L\right]} = \frac{\alpha}{20\left[\frac{n\,(n-1)}{2}\,\frac{C}{L} + n\right]} \quad (4)$$

This shows the maximum permissible change in the grade rate per car length in order never to have compression in any of the couplings. Notice the train, as a whole, may be increasing or decreasing in velocity, and that any force the locomotive exerts above

Q affects the train as a whole to accelerate its velocity, or, if not large enough for this, to keep the train from decreasing in velocity as fast as it otherwise would, due to the normal train resistance.

If the train is so long that it may more than cover the whole curve, which would, in practice, be the most common case, then as

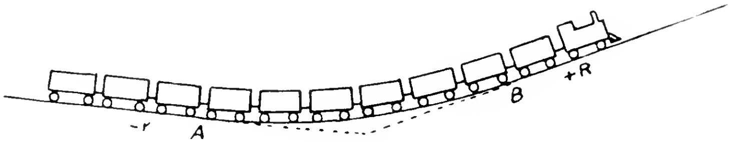


FIG. 10.

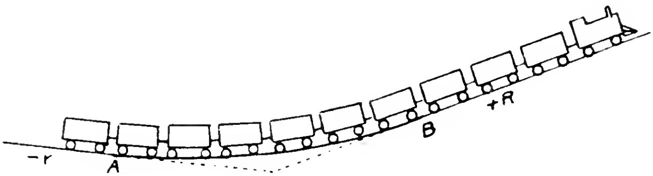


FIG. 11.

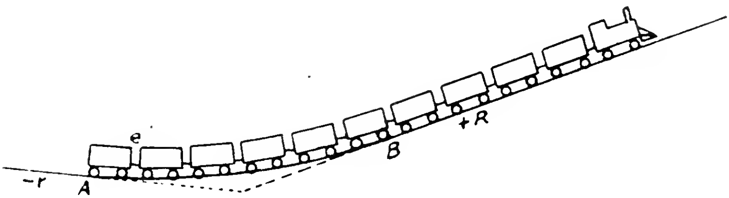


FIG. 12.

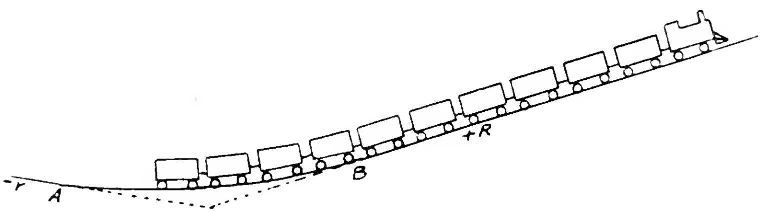


FIG. 13.

the train passes from the left toward the right it would occupy some such position as that shown in Fig. 10. Notice as the locomotive passes A, moving from the left toward the right, the Q required to keep compression from the couplings before the locomotive reaches B is as discussed above, and as shown in Fig. 6. After the locomotive has passed B, if compression can be kept from

the coupling over A, none of the cars to the rear of A will crowd up to those ahead of A. With the train in the position shown in Fig. 10, the value of α L must be at least equal to Q to keep compression from the coupling at A. In this case

$$\alpha L = 20\beta\left[\left(\frac{1}{2}+\frac{3}{2}+\frac{5}{2}\ \cdot\ \cdot\ \cdot\ \frac{2a-1}{2}\right)C + aC(n-a-d)+aL\right]$$

$$= 20\ \beta\left[\frac{a^2\ C}{2} + a\ C\ (n-a-d) + a\ L\right] \qquad (5)$$

Substituting for β its value, $\frac{R-r}{a}$,

$$\alpha\ L = 20\ (R-r)\left[C\ n + L - \frac{a\ C}{2} - C\ d\right] \qquad (6)$$

For any positive value of a, α L evidently has a maximum positive value when d is as small as possible, which in this case would be 1 (see Fig. 11). Making d equal to 1,

$$\alpha\ L = 20\ (R-r)\ \left[C\ n + L - \frac{a\ C}{2} - C\right] \qquad (7)$$

Solving for a,

$$a = 2\ n - 2 + \frac{2\ L}{C}\left(1 - \frac{\alpha}{20\ (R-r)}\right)$$

$$= G - 2 \qquad (8)$$

where

$$G = 2\ n + \frac{2\ L}{C}\left(1 - \frac{\alpha}{(20\ R-r)}\right)$$

Notice a must be less than n, as it was so assumed in deducing the equation.

If the rear car has just passed A, the train will be in the position shown in Fig. 12. With the train in this position, the value of α L must be at least equal to Q to keep compression from the coupling at e. In this case,

$$\alpha\ L = 20\ \beta\ \Big[\ (1+2+3\ .\ .\ .\ .\ .\ .\ (a-1)\ )\ C + \frac{2\ a-1}{2}$$

$$(n-a)\ C + \frac{2\ a-1}{2}\ L\Big]$$

$$= 10\ \beta\ \left[a(a-1)C+(2\ a-1)\ (n-a)C+(2\ a-1)L\right] \qquad (9)$$

$$= 10\ \beta\left[(2\ a-1)\ (n\ C+L) - a^2\ C\right] \qquad (10)$$

Substituting for β its value, $\frac{R-r}{a}$,

$$\alpha\ L = 10\ \frac{R-r}{a}\left[(2\ a-1)\ (n\ C+L) - a^2\ C\right] \qquad (11)$$

Solving for a,

$$a = \frac{G}{2} \pm \sqrt{\left(\frac{G}{2}\right)^2 - \left(n + \frac{L}{C}\right)} \tag{12}$$

This value of a represents the length of the vertical curve necessary to keep compression from the coupling between the two rear cars when the rear one has just passed on the curve.

If the train is moving off the curve to the right, equation (10) will give the value of α L or $\underset{\sim}{Q}$ to keep compression from the coupling between the two rear cars, and therefore all other couplings, if we replace a by a′ where a′ represents the number of cars remaining on the curve at the rear end of the train, Fig. 13. If $\underset{\sim}{Q}$ and a′ be considered as variables, and β and n as constants in equation (10) where a′ has replaced a, and then this expression be differentiated, we have

$$d\,\underset{\sim}{Q} = 20\,\beta\,(n\,C + L - a'\,C)\;d\,a'.$$

As n C is always larger than a′ C, the expression n C + L — a′ C is always positive. This shows that as a′ decreases, or as a′ receives a negative increment, that $\underset{\sim}{Q}$ will also decrease. Therefore, the demand on the locomotive to keep compression from all the couplings is less with the train as shown in Fig. 13 than as in Fig. 12, and the locomotive must exert its maximum pull to keep compression from the couplings when the train is in the position shown by either Fig. 11 or Fig. 12. This applies to the train when it is so long that it more than covers the vertical curve.

A careful study of these equations shows certain interesting things and develops certain practical limitations. Subtracting the value of a in equation (12) from its value in equation (8) gives

$$10\,\beta[L + C\,(n - a) - a\,C] \tag{13}$$

L + C (n — a) and a C are the weights of the parts of the train off and on the curve, respectively; so this shows that with any curve of length a, when more than half the weight of the train is off the curve, the $\underset{\sim}{Q}$ is larger with the train as shown in Fig. 11 than as shown in Fig. 12; but when more than half of the weight of the train is on the curve, $\underset{\sim}{Q}$ is larger with the train as shown in Fig. 12 than as shown in Fig. 11.

Placing the value α L in equation (7) equal to that in equation (11) and solving for a, we have,

$$a = \frac{1}{2}\left(n + \frac{L}{C}\right) \tag{14}$$

This is the value of a for which the demand on the locomotive to keep compression from all the couplings will be the same, whether

the train is in the position shown in Fig. 11 or Fig. 12. This special value of a is only dependent upon n and $\frac{L}{C}$. It is the same whatever the value of α and (R — r). If this value of a be substituted in either equation (8) or equation (12) and then the equation be solved for n, we shall have,

$$n = \frac{\alpha L}{15 C (R - r)} + \frac{4}{3} - \frac{L}{C} \tag{15}$$

This gives the number of cars in the train when the required curve length is the same by equation (8) and equation (12) for any assumed value of α, L, C and (R — r).

Consider equation (12) in detail. The quantity $\left(n - \frac{L}{C}\right)$ is always plus. In order to have equation (12) give a *real* value of a, the quantity under the radical must be real. In order to have it real $\left(\frac{G}{2}\right)^2$ must be $\geqq n + \frac{L}{C}$. Placing $\left(\frac{G}{2}\right)^2 = n + \frac{L}{C}$, we have $\frac{G}{2} = \pm \sqrt{n + \frac{L}{C}}$. The value of $\frac{G}{2}$ cannot be less than this and have the quantity under the radical real.

The quantity G, which equals $2n + \frac{2L}{C} - \frac{\alpha L}{10 C (R - r)}$, can easily be either plus or minus in the limits of the problem. If α is zero, it is plus. α can be practically any value from zero to 400 or 500. $\frac{L}{C}$ will be large if the train is made up of light cars and a heavy locomotive. (R — r) can have any positive value (see page 141). In order to make G negative, it is necessary to have $\frac{\alpha L}{10 C (R - r)} > 2n + \frac{2L}{C}$, which is easily done, as, for example, let α equal 300, $\frac{L}{C}$ equal 8, (R — r) equal 0.2 and n equal 10, when G becomes — 1164. This, of course, would make $\left(\frac{G}{2}\right)^2 > n + \frac{L}{C}$, which is necessary to have the quantity under the radical real, and therefore a real value of a.

Suppose $\frac{G}{2}$ has any value $\geqq \sqrt{n + \frac{L}{C}}$, and is either plus or minus, then its square would be $\geqq n + \frac{L}{C}$, and would be plus. But whatever its numerical value, if from it we subtract the second part of the quantity under the radical, or $n + \frac{L}{C}$ the difference will be

less than the value of $\left(\frac{G}{2}\right)^2$. Therefore the part under the radical would be greater than $\frac{G}{2}$, which would make the value of a by equation (12), if a real value, a negative quantity if $\frac{G}{2}$ is minus, and positive if $\frac{G}{2}$ is plus, whatever the sign before the radical. Also, from what has been said, it is readily seen that as $\frac{G}{2}$ can be either plus or minus, so equation (8) can give either a plus or a minus value for a, but always real. Any combination by which we obtain a negative value of a for both equation (8) and equation (12) means that no vertical curve is necessary to keep compression from the couplings, and that the pull of the locomotive is being used, in addition to keeping compression from all the couplings, to overcome the normal train resistance in whole or in part, or even to accelerate the velocity of the train, so we are only practically concerned with cases giving positive values of a.

To find whether a by equation (8) or by equation (12) is the larger when the value of a is positive, let a by equation (8) equal a_8, and a by equation (12) equal to a_{12}, and call $s = a_8 - a_{12}$, then

$$s = \frac{G}{2} - 2 - \sqrt{\left(\frac{G}{2}\right)^2 - \left(n + \frac{L}{C}\right)} \qquad (16)$$

Differentiating, we have

$$d\,s = \frac{1}{2}\left(1 - \frac{\frac{G}{2}}{\sqrt{\left(\frac{G}{2}\right)^2 - \left(n + \frac{L}{C}\right)}}\right) d\,G \qquad (17)$$

It has been shown above that to make a positive, G must always be positive, and that $\sqrt{\left(\frac{G}{2}\right)^2 - \left(n + \frac{L}{C}\right)}$ is always less than $\frac{G}{2}$; therefore $\frac{\frac{G}{2}}{\sqrt{\left(\frac{G}{2}\right)^2 - \left(n + \frac{L}{C}\right)}}$ is always greater than 1, and it follows that $1 - \frac{\frac{G}{2}}{\sqrt{\left(\frac{G}{2}\right)^2 - \left(n + \frac{L}{C}\right)}}$ is always negative for any value of $\frac{G}{2}$ for which a is positive. Therefore if G be given an increment, d G, the corresponding increment of s, or d s, will be negative. At some point $a_8 - a_{12}$, or s, is zero, or when

$n = \frac{\alpha L}{15 C (R - r)} + \frac{4}{3} - \frac{L}{C}$; so for any value of G less than that value for which $a_8 = a_{12}$, or s = zero, s must have been plus in order to have negative increments make it equal to zero, and therefore, for any value of G greater than that for which $a_8 = a_{12}$, s will be negative.

In applying the formulæ to determine values of a, certain values would be assigned to n, α, L and C or $\frac{L}{C}$. Then of the terms in the value of G, or $2\left[n + \frac{L}{C} - \frac{\alpha L}{20 C (R - r)}\right]$, (R — r) would be the only variable. Under these conditions, G receives a positive increment only when (R — r) increases; therefore when (R — r) is less than that value for which $a_8 - a_{12}$ is made zero, a_8 will be larger than a_{12}, and when (R — r) is greater than that value for which $a_8 - a_{12}$ is made zero, a_{12} will be greater than a_8. To determine theoretically the proper length of vertical curve to be put in, the larger of the two quantities a_8 and a_{12} should be used.

A graphical representation is often clearer than a mere inspection of equations. For this reason diagrams have been constructed for equations (4), (8) and (12) with assumed values of $\frac{L}{C}$ and α. An inspection of equation (8) shows that if we wish to assume values of L and C to give rather large values of a, L must usually be rather small, and C large, as, except for small values of α, $\frac{\alpha}{20 (R - r)}$ would be negative. Probably $\frac{L}{C} = 2$, the value used, would be a fair one. α is taken as 100, 200, 300 and 400. In assigning these values to α, the tender has been considered the same as a car and not included in L. If the tender is included in L, the values of α should be taken smaller. As L includes the weight of the pilot as well as the weight on the drivers, $\alpha = 400$ would correspond to a coefficient of adhesion of about 0.25.

The diagrams are largely self-explanatory. Fig. 14 gives maximum values of β, in order never to have compression in the couplings, for values of n and α from equation (4). With this equation, of course, a cannot be given, as the train does not cover the whole curve. Fig. 15 gives values of a, in order never to have compression in the couplings, for values of (R — r) and α by equation (8), and also shows when a, by equations (8) and (12), has the same value (at all points on lines marked A). Equation (12) is plotted on Fig. 15 for $\alpha = 200$ for two values of n as dotted lines. This shows how little difference there is between values of a, by equations (8) and (12), when (12) gives the larger value. As equations (4) and (8)

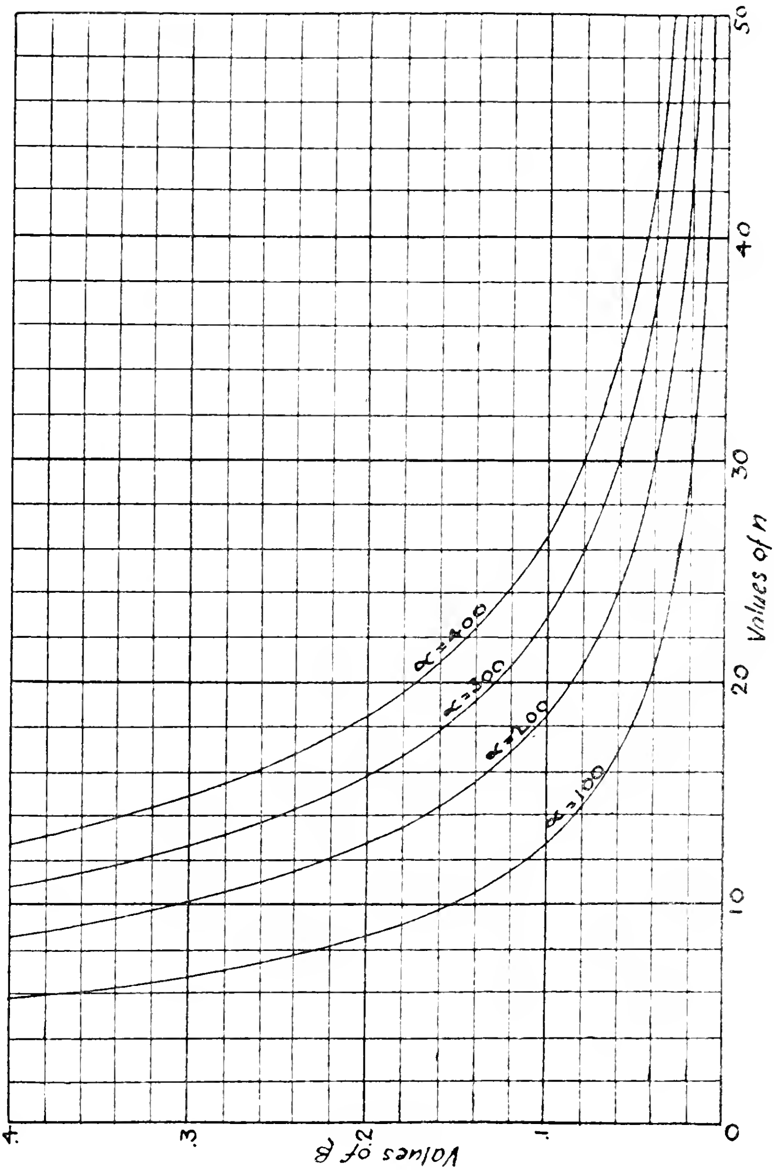


FIG. 14.

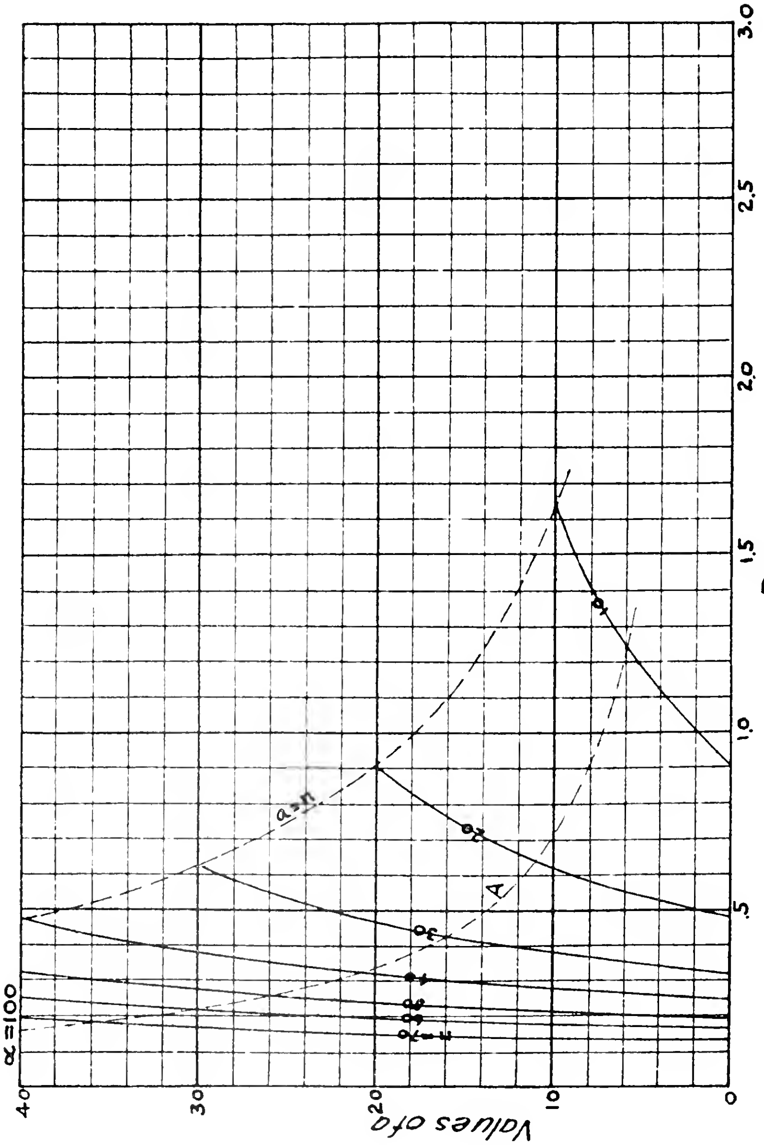


Fig. 15-α = 100.

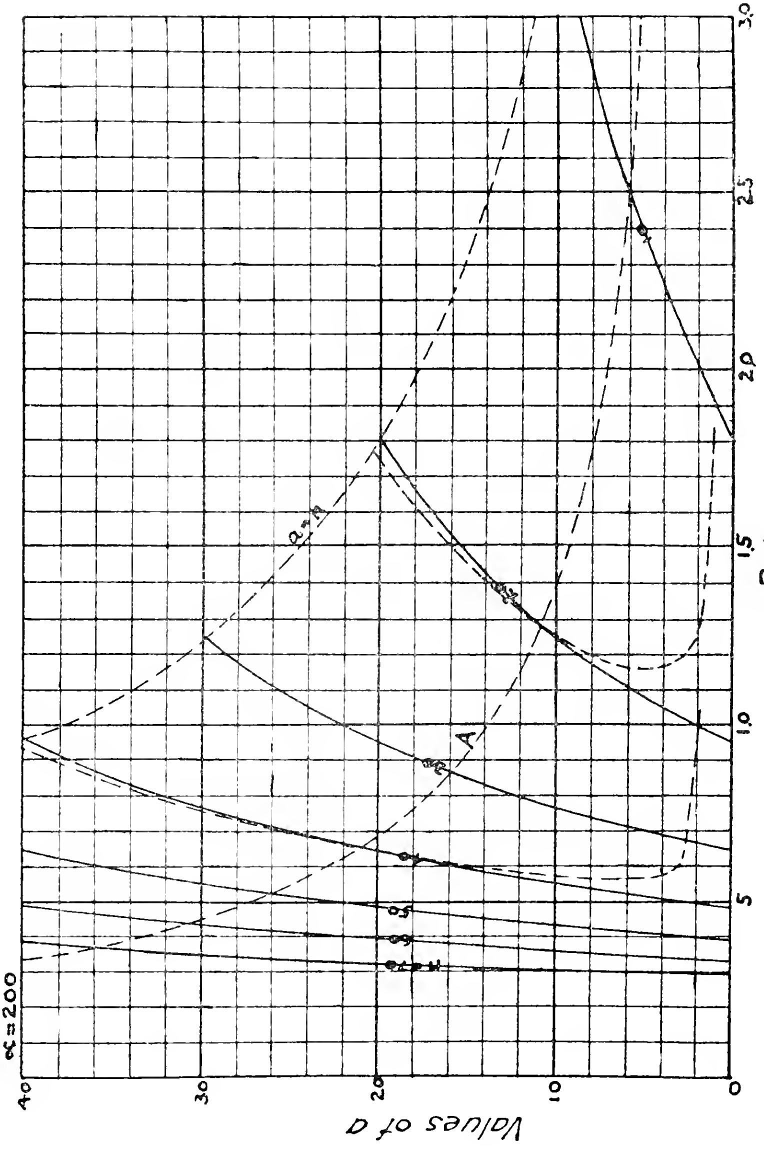


Fig. 15-α = 200.

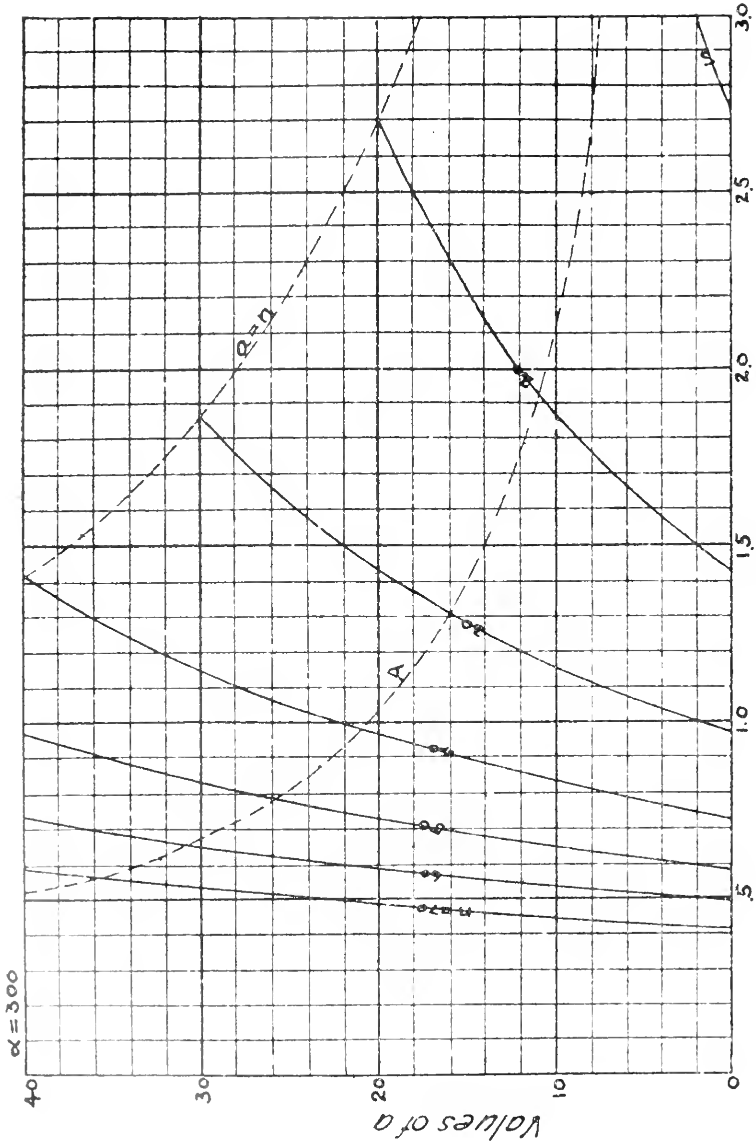


FIG. 15—α = 300.

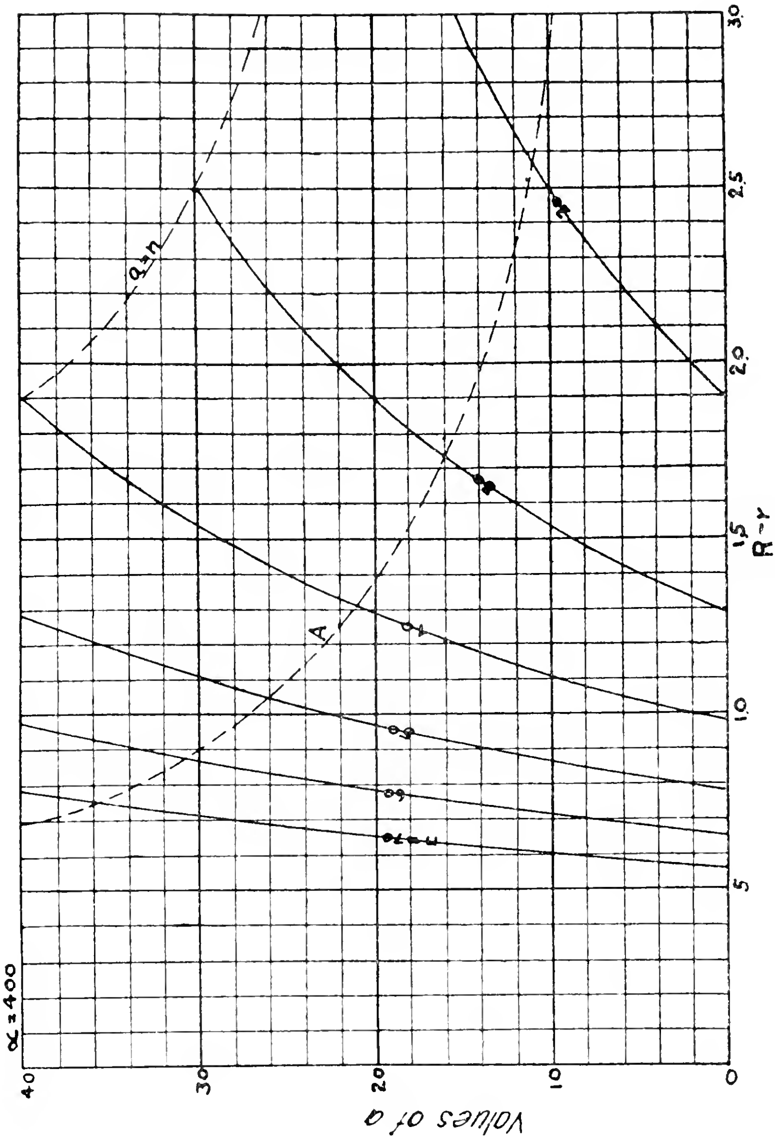


FIG. 15-α = 400.

are of sufficient range to cover the most usual cases that would occur in practice, and are simpler than equation (12), a study of them, or their graphical representations, will satisfy all practical requirements.

Fig. 15, in particular, shows that in passing sags, vertical curves of lengths ordinarily used have a very small effect in keeping compression from the couplings of long trains, and that it is only when the trains become short that the vertical curves have any considerable effect for this purpose. For instance, from Fig. 15, when $a = 300$ and $n = 40$, we may have a change in grade rate of nearly 0.75 and no vertical curve, and yet have no compression in the couplings. With a curve 12 car-lengths long, this change in rate could be increased to about 0.85, or the effect of the curve is small. If $n = 20$, a change in the grade rate of 1.45 can be made with no vertical curve; while with a curve 12 cars long, the change can be 2, or the effect when the train is short is much greater than when the train is long. Moreover, it can be seen that a relatively small increase in a would enable the change in grade rate to be increased as much. To have the locomotive pulling hard in passing the sag is much more effective in keeping all couplings in tension. This shows why "pulling out" by the engineer at such places is productive of good results. Brakes set on the cars *at the rear end of the train* would also be effective, as this would keep the rear cars from crowding upon the forward ones. But it would hardly be practicable in ordinary service to set the brakes on the rear of the train, and on the rear only, at such places. Atmospheric resistance from suction on the rear car of the train would have a similar effect to that of applying the brakes on the rear car of the train.

It is very probable that no serious jerk would occur even if there were momentarily a small compression on the couplings at a few of the cars in the train, and so it is very likely that curves considerably shorter than those shown to be theoretically necessary would satisfy all practical requirements.

CONCRETE-STEEL.

By M. C. Couchot, Member of the Technical Society of the Pacific Coast.

[Read before the Spring Meeting of the Society, May 27, 1904.]

The aim of this paper is to bring before the members of the Technical Society a short description of this new and promising system of construction and some of its recent applications in the United States, and to show some of its prominent advantages.

Concrete-steel, as its name implies, consists of the combination of (1) concrete with (2) steel or iron; two very different materials—one ideal for compression, the other ideal for tension, and using the qualities and properties of both to the greatest advantage and economy.

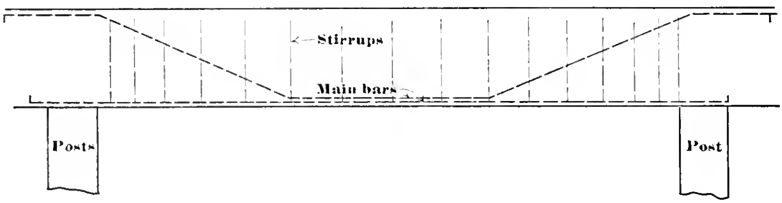
There is no doubt that the combination of these 2 materials was made years ago, but it is only of recent date that a systematic application has been used. Twenty and some years ago, Jean Monier conceived the idea of making some flowerpots of beton with a wire netting imbedded in the beton. These flowerpots were satisfactory. Then he made some water pipes, also some floor slabs, and obtained certain patents which were afterward exploited by the firm of Wayss, of Berlin and Vienna. This firm began to make some practical experiments, and to them we are indebted for the first tangible information regarding the internal work of concrete-steel. The Monier system then began to be extensively used in Europe, but principally in Germany and Austria.

This success brought others into the field, and very soon we had a number of different systems—some simple, some complicated.

About that time, 1886-87, Messrs. Ransome, in the United States, and Hennebique, in France, began the construction of floors of a larger span than had ever been attempted before. Their systems were practically identical, Mr. Ransome using square rods previously twisted and Mr. Hennebique using plain round rods. Mr. Ransome was then in California, and the work he left behind him attests his sound judgment, for at that time the theory of concrete-steel was still in embryo.

From the floor slabs to the beams there was but one step. At first the beam was treated as a narrow strip of slab having sufficient reinforcement at the lower portion to take care of the tension strains, the concrete taking care of the compressive strains as well as the shearing strains in the body from the center to the supports. Prac-

tice soon showed that concrete alone was not sufficient to take care of these last strains, as numerous cracks would make their appearance long before the reinforcement or even the extreme upper fibers in the concrete would be anywhere strained to their working capacity. Mr. Hennebique was the first one to introduce his system of stirrups to take care of the shearing strains. His disposition of the reinforcement in concrete beams is now generally adopted as standard, filling well all the needs. I give below a small sketch showing the general arrangement.



Concrete-steel beams generally have a rectangular section. The reinforcement consists of an even number of plain or deformed rods imbedded in the lower portions of the beam. All rods run parallel for a distance equal to about one-third the length of the span in the center. Half of them keep the lower edge the full end of the beam, and the other half reach to the corresponding position in the upper part of the beam over the supports, following the lines of maximum moments in a fixed end beam. A number of stirrups run vertically in the Hennebique system and at different inclinations in some other systems. These stirrups are generally some small-sized rods or wire, all of the same section. They are spaced closer as the shearing strains increase from center to support. The amount of steel reinforcement varies from 0.75 to $1\frac{1}{2}$ per cent. of the total sections of the beam, according to conditions.

The construction of pillars or columns was then only a matter of course. The reinforcement consisted of rods, generally plain, set vertically near the outer portions of the columns and tied together at regular intervals by small rods or flat bars of iron, varying with the loads. The reinforcement amounts to 1 to 2 per cent. of the sections of the column, according to conditions.

I may also say that the steel may be stressed to 16,000 pounds per square inch and a 1-2-4 concrete of good material may be strained to 700 pounds per square inch after a lapse of 6 months; these figures cannot be used for all cases, but only when materials used and working conditions justify it. The concrete is not figured

to take tensile strains except in some certain cases when it cannot act otherwise.

We now have the requisites for nearly all kinds of structures—the slab, the beam and the columns. The rest need be but curtain walls and partitions, also susceptible of the same treatment.

We have seen the evolution of concrete-steel from a flowerpot to a complete rigid, homogeneous frame. The theory has closely followed practice (a seemingly reverse order of things, but actually so), and we are now in possession, from theory and some empiric data, of a fair knowledge of the internal work of concrete-steel. I will not enter into a description of the theory or theories, as they are readily accessible; I will confine myself to a few words on some of the recent applications of concrete-steel in the United States and of the advantages of this new system of construction.

While in Europe the application of concrete-steel embraces nearly all constructions in the domain of the civil engineer and the architect, the adaptation of this method in the United States has been rather slow. It is only within the last few years that concrete-steel work of any magnitude has been constructed.

The advantages that may be claimed for concrete-steel construction are many. Among them can be mentioned the facility for obtaining the materials almost anywhere, the rapidity of erection, the reduction of skilled labor to a minimum; its economy, giving practically a structure having the strength and durability of masonry without its bulk and with the elasticity of steel, and at a cost greatly below the two; its imperviousness when properly treated; its great fire-resisting quality, as I will show later; the fact that both of the materials have practically the same coefficient of expansion; that they will not tend to slip away, but will work together; that the steel once imbedded in the beton will have a complete and permanent protection from the elements which is hardly obtainable in other systems. All of these advantages ought to give concrete-steel a more prominent place among the other systems of construction by engineers and architects. The movement is now forging ahead in the Eastern States. It will not be long before we will be following out here in the West, and in a few years I firmly believe the United States will be ahead of Europe in the application of concrete-steel to all kinds of structures.

Among the recent and most prominent works in the last few years I will cite only a few, as follows:

A 16-story office building in Cincinnati, built entirely on the Ransome system, 50 x 100 x 210 feet high (as high as our "Call" building), having concrete-steel beams of 16 and 33 feet spans; floor

panels, 16 x 33 feet, and columns 12 x 12 inches to 36 x 36 inches. The height from floor to floor in the upper stories was 12 feet 6 inches. This construction permitted a saving of 1 foot in the height per floor on account of the shallow floors, which is quite an item in a 16-story building. The facing of this building consisted of a veneer of marble 4½ inches thick for the first and second stories and 4½ inches of glazed brick for the remaining stories, with terra-cotta cornices and trimmings, showing that the use of concrete-steel does not interfere with the architectural effect that may be desired. Another point—the rate of erection was 2½ stories per month for the concrete work.

A court house for Nassau County, Long Island, N. Y. A monolithic concrete-steel building, 176 x 37 feet in the main part, with an extension of 60 x 52 feet; the building is 2 stories high, with a dome 25 feet in diameter rising 62 feet above the roof. The foundations, walls, columns, roof, dome and ceiling are all of concrete-steel; the floor is made to stand a load of 150 pounds per square foot. This building is also built on the Ransome system.

The beautiful highway bridge at Topeka, on the Kansas River, erected by Mr. Edwin Thatcher. This is one of the most important pieces of work in concrete-steel in the world, consisting of 5 arches of 125, 110 and 97½ feet respectively, built on the Melan system. It has already withstood two floods that have destroyed nearly all other steel and frame bridges in the neighborhood.

The great Miami River highway bridge at Dayton, Ohio, 56½ feet wide and 558 feet long, consisting of 7 three-centered arch spans, designed also on the Melan system by Mr. Edwin Thatcher. It is erected for a floor load of 150 pounds per square foot and a 40-ton electric car on each car track. The bid for concrete-steel was $140,-000 for this work, and was lower than any other bid for a steel truss bridge.

A factory for Kelley & Jones, at Greensburg, Pa., 60 x 300 feet. It is a 4-story building, constructed entirely of concrete-steel, on the Ransome system.

Another factory and warehouse for the Central Felt and Paper Company, of Long Island, N. Y., 112 x 312 feet. This building rests on a pile foundation, and was first designed for wood construction, but the owners changed to concrete-steel, and the cost did not exceed 15 per cent. more than the wooden construction. This building is remarkable for the fact that it contains concrete-steel beams or girders 52 feet clear span—a rather long one, indeed—and these beams have to support the roof with a water tank on top of it. The dimensions of the girders are 52 feet long, 30 inches

deep, 15-inches wide, and have nine $1\frac{3}{8}$-inch rods for reinforcement at the bottom and six $1\frac{5}{16}$-inch rods at the top, the stirrups being only $\frac{3}{16}$-inch wire.

In a hall of music at Cincinnati, by L. Mensch, built on the Hennebique system, there are girders of 61 feet span under the balcony.

A water tower or standpipe near Boston, for the United States Government, built on the Hennebique system, is 20 feet in diameter and 50 feet high; the thickness of the wall at the base is only $6\frac{1}{4}$ inches, with 1 inch of Portland cement plaster, making this structure completely water-tight. Again, in this case, the bid was 30 per cent. lower than any other.

There are two 45-foot spans for a highway bridge at Santa Monica, erected by Luten on a system of his own, showing what could be done for small spans in many places in California, which are now spanned with steel or wooden structures which need constant repair and attention (which is seldom given to them by our city and county supervisors); while a concrete-steel bridge would cost but very little more in the beginning and would not require any attention whatever.

Concrete-steel for culverts and bridges in railroad work are coming into use more and more every day, and their cost (even for large spans) compares very favorably with masonry and steel spans, the latter having to be changed every generation due to the increase in rolling stock.

The Roxborough filters for the Philadelphia filter system are composed of posts and groined arches, reinforced with expanded metal and corrugated bars.

There is a chimney in Los Angeles for the Pacific Electric Railway Company which is 180 feet high, made of 2 concentric rings, one 15 feet 2 inches and the other 11 feet in diameter, the outer shell being only 9, 6 and 5 inches at different heights; the inner shell is 5 to 4 inches—all built on the Ransome system.

There is a pile foundation for the Hallenbeck Building, New York, which dispensed with the use of costly caissons and piers; the piles are 12 inches square, 28 feet long, and the reinforcement consisted of four $1\frac{7}{16}$-inch rods. Each pile was to take a load of 80,000 pounds. This was built on the Hennebique system.

The Stadium at Harvard, with a seating capacity of 40,000 (resembling in a way the Roman Coliseum), is 570 x 420 feet, the outside wall being 53 feet high. This building was designed by Charles F. McKim.

There is also the intercepting sewer for Cleveland, Ohio, 14 feet in diameter and $3\frac{1}{2}$ miles long, built on the Parmley patent.

The coal storage bin for the Lowell Gas Light Company, Lowell, Mass., with a capacity of 25,000 tons.

A storage bin for cement for the Illinois Steel Company, consisting of 4 bins, 25 feet in diameter and 54 feet high, with a capacity of 25,000 barrels, built on the Monier system.

A grain elevator in Ontario, with a capacity of 500,000 bushels, each tank being 30 feet in diameter and 70 feet high.

An example of the resisting qualities of concrete-steel against fire may be cited. In Baltimore there was an old building in which the outside walls were of brick and the inner frame of the ordinary construction of wooden posts, wooden beams and wooden floors. Before the fire this building was entirely remodeled and the inside wooden frame was replaced by concrete-steel frame; that is, all of the columns, beams and floors were changed, only the brick wall being retained. The terrible fire came; everything in the block where this building stood was completely gutted. After the fire there was nothing left but the concrete-steel frame, which stood there mute, but more impressive and eloquent than any words can express. Two weeks after the fire the floors in this building were loaded with 300 pounds to the square foot, and stood this test, showing that the fire had not in any way impaired the strength of the columns, beams and floors.

In all of the above I have shown the actual application of various systems of concrete-steel to a number of different structures, among which are office buildings, factories, warehouses, chimneys, coal and ore bins, grain elevators, filters, sewers, court houses, theaters, hospitals, schools, water towers, bridges, railroad culverts, stairs, etc.

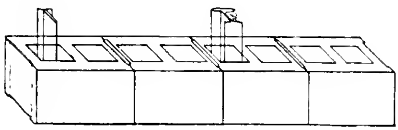
I could continue this list, but it would only be a repetition of itself. I hope that this paper will awaken in the members of this Society and in engineers and architects at large, a desire to familiarize themselves with this new construction, and that it may become of universal benefit.

A NEW METHOD OF BUILDING CONSTRUCTION.

By S. Giletti, Member of the Technical Society of the Pacific Coast.

[Read before the Spring Meeting of the Society, May 27, 1904.*]

The writer herewith intends to present to the Technical Society some recent improvements in the construction of walls, partitions and floors for business blocks, residences and other structures hitherto constructed of stone or steel. Ordinarily, in the erection of such structures, the steel skeleton frame is first reared, then the stone, brick or terra cotta are placed around this frame. The plan now to be described provides a method of construction in which the walls are built first, raising them story by story, and, as each story is raised, the metallic frame is inserted in flues left open for this purpose. The flues, of concrete hollow blocks, where the metallic column is placed as designated, are filled in, binding the whole into one rigid and indestructible body.

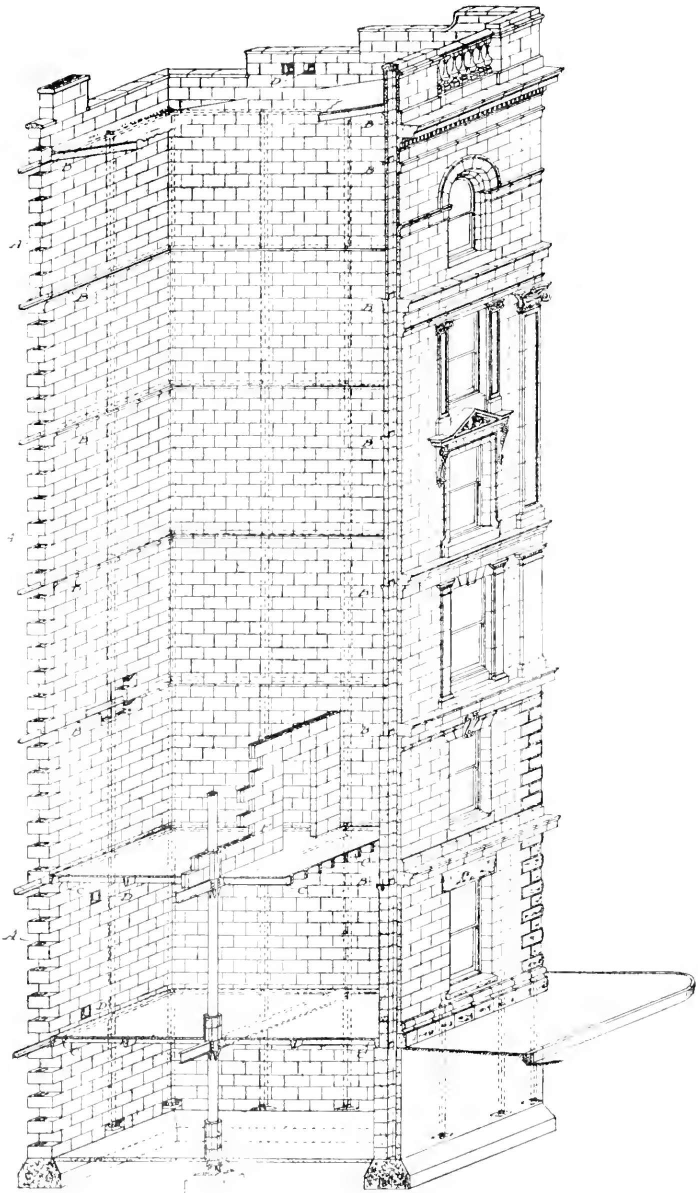


In the system commonly used, where the steel frame is first erected, the metal must be painted in order to protect it from rusting; then, when stone or brick is built around it, the paint forms a most effectual means of keeping the stone or brick and the metal apart. In our case, however, the concrete wall is first built up, and then the parts of the steel frame are inserted in the flues. As each piece can be cleaned just before its insertion, it is entirely free from rust. As the flue is then filled in with concrete, the latter unites with the metal, protecting it from rust for an indefinite period; and, because their coefficients of expansion are equal, the two parts form really one mass.

Usually the steel frame of a building is inaccessible after its completion, and deterioration cannot be observed. In our case no anxiety in this regard need be felt, for the steel is preserved in the best possible manner.

The outside surface is made in imitation of sandstone, or it may be made to imitate any kind of granite, or even brick.

* Manuscript received June 20, 1904.—Secretary, Ass'n of Eng. Socs.



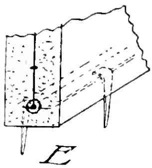
Through the hollow artificial stone blocks flues are provided, about 8 inches, more or less, square; these flues start from the foundation of the building and continue to the top of the main cornice in vertical lines. The dimensions of the hollow blocks may vary, according to the size and capacity of the structure. The belt courses, cornices and ornaments of the outside of the building may be made in

part of hollow blocks, cast in the same mold, so as to make a perfectly sound stone.

The surfaces of the hollow blocks, forming the interior walls of the structure, are made rough enough to form a perfect key to receive and hold the plaster, thus avoiding the necessity of the use of any kind of lath.

Upon the last or upper course of each story there is provided a projection (B) from the interior vertical line of the walls. This projection provides a proper bearing for steel girders or wooden joists.

The hollow blocks mentioned, which form the walls of the building, rest upon a solid foundation made of concrete, and through the interior wall of the lower courses of blocks there are provided openings, from 5 to 8 inches square, so as to afford ventilation or to give access to heaters, thus enabling the occupants, by a proper regula-



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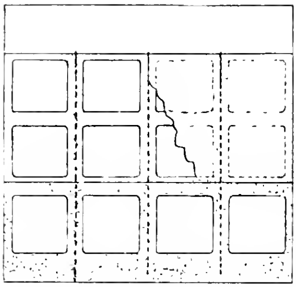


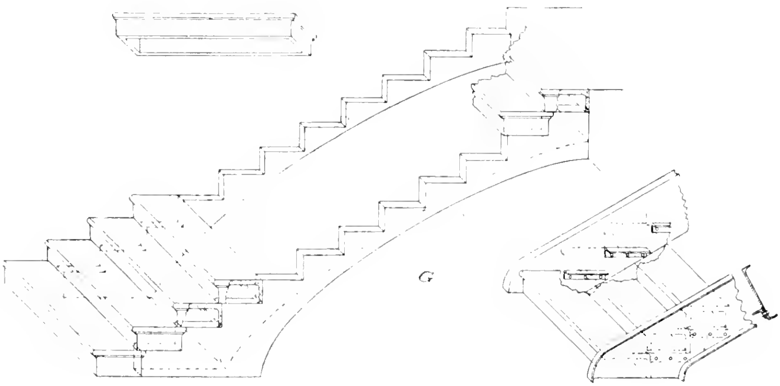
tion of the ventilators, to keep a current of cool air running through the exterior walls of the building during the heated days of summer, and also to convey heated air from the furnaces to any part of the structure in winter, by carrying the furnace conduits to such flues as connect with the various parts of the structures which it is desired to heat. Other flues may be used as conduits for plumbing pipes and electric wires, also for speaking tubes.

It will likewise be observed that the hollow flues afford an opportunity for placing stoves or other heating apparatus in any of the rooms of the building at the will of the occupant. This will be found particularly desirable in the kitchen and laundry. The tops of the flues are covered, at the cornice or fire walls, with solid stone, except, of course, in the case of chimneys or ventilators. This stone can be pierced or closed at will, so as to change the flues if desired.

The fireproof arched floors consist of concrete beams, E, reinforced with steel plates and forming small arches, as shown on the plans. No. I-beams or girders are needed for spans up to 30 feet

from wall to wall, or from I-beam to wall. This floor will carry 316 pounds to the square foot. The arches weigh about 40 pounds per square foot. With this system there is no need for any iron frame to support the iron lath for the ceiling, as seen from plans and section, E. By making the sheet steel beams heavier and placing the girders closer together any desired load may be carried.

The interior partitions are fireproof; they are 4 inches, more or less, in thickness, including the plaster, and they are made of cement, cinders and galvanized wires. The wires are $\frac{1}{4}$ inch in thickness, and run vertically from floor to ceiling, from 12 to 24 inches apart, according to the height of the story and to the strength required. The wires are to be placed opposite to one another, on each side of the partition, and a small wire is to tie both galvanized wires in every course of cement and cinder tile, so as to form a perfectly rigid



and solid body. After the partitions are built up, they may be plastered on both sides in the usual way. The weight of partition, including tile, plaster and wire, is about 22 pounds per square foot.

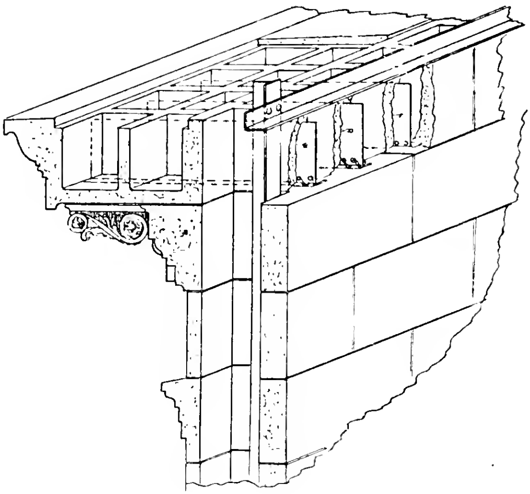
The stairs are constructed upon the same principle as the arches, as per plans and section, and the material is cement and marble composite; the treads and risers form one solid piece and the interior of the step is hollow, its weight being about 35 pounds per lineal foot. The steps can be laid on iron, wood or concrete arches as strings. The latter is preferable, is more fireproof and gives more satisfaction in shape and economy.

In order that builders may better appreciate the advantages of this method of construction, it is necessary to describe briefly the manner in which the hollow blocks of artificial stone are made.

A mold is used, with a core, having its walls connected by a bar extending centrally through the core, whereby the size of the

core may be increased or reduced, according as the links are operated, while inserting the core into the mold or withdrawing it therefrom. When it is desired to remove the core, the simple act of the operator taking hold of the handle of the bar and giving a moderate pull causes the links to turn on their pivots, freeing the casing from the surrounding stone or cement, and the core is withdrawn through a hole on one side of the mold, leaving the still green block entirely uninjured. It is not necessary to wait for the block to dry. The core is unaffected by moisture, and is ready for any design, style or size of hollow artificial stone or tile.

Hitherto it has been impossible to obtain a perfectly sound artificial stone block. This is due to the fact that, while filling the



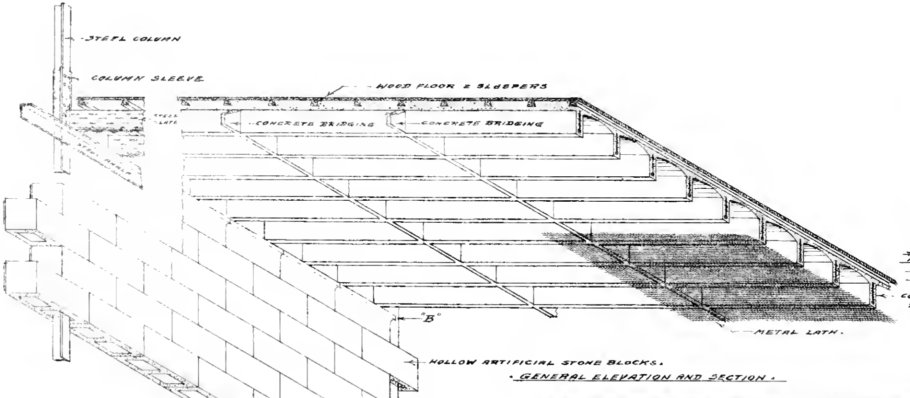
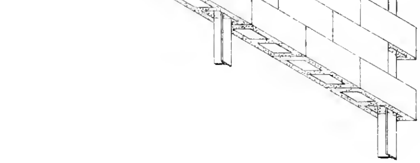
mold or plaster cast hitherto universally in use, the moisture contained in the cement or concrete would get into the apparatus or mold, and, becoming imprisoned in the block, would cause the stone to swell after its release from the mold. This swelling necessarily produces a crack. The crack, however, does not manifest itself until the block begins to dry or even after the block has been actually set in the building. Concrete workers have not as yet been able to overcome this unfortunate condition of affairs except by the use of the core above described. By use of this, however, blocks of stone, either hollow or solid, may be manufactured, turned out and preserved as free from cracks as native stone. This great advantage now renders possible buildings of artificial stone as solid and durable as granite.

The cost of constructing walls of common brick on the outside

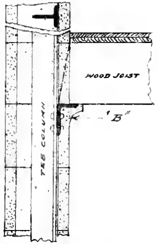
and lathing within, and having terra-cotta chimney flues with heater and ventilator conduits, according to the old style, averages in San Francisco, Cal., 55 cents per cubic foot. A brick building, with sandstone front, constructed in like manner, would average 90 cents per cubic foot. If constructed with granite front it would average $1.25 per cubic foot. These figures place the construction of such buildings practically beyond the means of the middle class and make them possible only to the wealthy. Even for such people the cost is so great as to reduce materially the rate of interest to be derived from their use.

The method herein described, as heretofore stated, does away not only with lathing, but also with furring, upon which the former must be put; it also does away with the terra-cotta or brick chimneys, and with heating pipes, ventilators and conduits. In addition to this, it obviates the necessity of the exterior plastering and painting, and much labor is saved in plumbing work throughout the building. These savings so reduce the cost that buildings may now be constructed of even greater durability than formerly and vastly more artistic in appearance. Much space is saved in the interior on account of the small thickness of walls, as the buildings constructed according to this method have walls of about one-half the thickness of those of the old-style brick and stone construction, and the cost is limited to 25 cents per cubic foot at the factory, or 42 cents placed in position. Not only is this great saving effected, but the building so constructed will be far more comfortable to the occupant as well as more healthful. In such buildings dampness is obviated, since no moisture can ever penetrate the hollow cement blocks. A better system of ventilation is possible and a more even temperature within can be maintained. It will readily be seen that this method of construction places owners in such an advantageous position as to preclude competition, and assures profits far in excess of ordinary business undertakings. To-day every improvement in construction is eagerly adopted, and this is so manifestly an advance in building practice, to say nothing of the saving effected, that it is worthy of every consideration on the part of those who are interested in building methods.

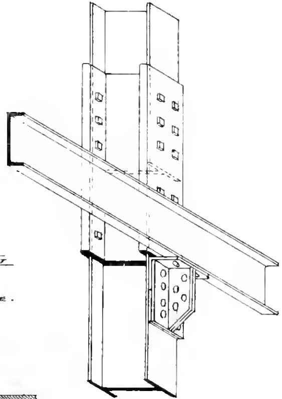
S. GILETTI PATENT SKELETON STEEL FRAME, HOLLOW ARTIFICIAL STONE BLOCKS AND FIRE PROOF FLOOR CONSTRUCTION

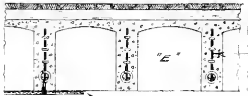
· GENERAL ELEVATION AND SECTION ·



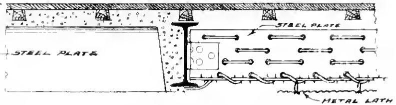
DETAIL SECTION SHOWING TEE COLUMN AND ANGLE TIE WITH PROJECTION ON HOLLOW BLOCKS FOR SUPPORT OF WOOD JOIST.



ALTERNATE DETAIL SECTION SHOWING I BEAM COLUMN WITH SLEEVE AND CHANNEL FOR FLOOR BEAM SUPPORT.



DETAIL SECTION SHOWING FLOOR BEAM CONSTRUCTION.



DETAIL SECTION SHOWING I BEAM GIRDER WITH STEEL PLATE OF FLOOR BEAM CONSTRUCTION.

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MANUFACTURE AND TESTING OF PORTLAND CEMENT.

By C. J. Wheeler, Member of the Technical Society of the Pacific Coast.

[Read before the Spring Meeting of the Society, May 28, 1904.]

The practice of using limes in binding stone, brick, and other building materials is one of great antiquity. The exact date of the discovery that calcined marble, or other pure limestone, slacked with water, would make a good cementing material is not known. The ruins of the Phœnicians and Egyptians show clearly that they were acquainted with its properties. The Romans, the greatest architects of the ancient world, were well acquainted with the use of limes, as also with certain methods of improving fat or pure limes in order to impart to them cementitious and hydraulic properties.

Vitruvius and Pliny describe methods for the manufacture and use of limes, and also certain additions to be made to them in order to give hydraulic properties.

The ancients believed and worked upon the principle that the harder the rock before burning, the better the hydraulic properties of the resulting product. This theory held sway from the time of the Romans up to 1776, in which year John Smeaton, an English engineer, in selecting a hydraulic material for the foundation of the Eddystone Lighthouse, made the discovery that the hydraulic properties of a lime depended not upon the hardness of the original limestone, but upon its clay content. This was the first real advancement which had been made in over 2000 years. From this time until 1824 a large number of patents were taken out in England on materials which resembled Portland cement and had some of its properties, but were called by different names. In 1824 Joseph Aspdin, a Leeds bricklayer, patented a process for the mixing and burning of lime and clay, and, in consequence of its fancied resemblance in color and in texture to the oolitic limestone from the island of Portland, which was then used in large quantities as a building stone, called it Portland cement.

For 50 years after Aspdin's first experiment very little advancement was made. A number of mills were operated in England, Belgium and Germany, but a very indifferent article was produced. Between the years 1870 and 1880 the attention of scientific men was called to the industry through the demand for a better hydraulic material in engineering work, and, while our knowledge at the present day is still limited in regard to the chemical reactions which

take place in the process of manufacture and setting, we still have made wonderful progress in the science.

The first Portland cement manufactured in the United States was made by the Copley Cement Company, at Copley, Pa., in 1875. Their initial output was very small, being about 2000 barrels the first year. From 1875 the industry has gradually spread until in 1903 the United States produced about 17,230,644 barrels.

The process of manufacture was formerly divided into 3 distinct systems—the wet, semiwet and dry. These have been so modified that at the present time we have only 2—the wet and the dry. The wet system is used very extensively in the marl district of this country and the chalk and mud districts of England. In other parts of the world the dry process is used almost exclusively. It will not be necessary to deal with each of these systems in detail, as they both aim at the same final result—the thorough incorporation of the lime material with the required proportion of clay material and the finest subdivision possible of the resulting product.

One of the most important if not the most essential point which a cement manufacturer has to deal with, is the fineness of the grind of his compound or raw material. No matter how well a cement mixture may be compounded and burnt or how fine the resulting cement clinker may be ground, if the raw compound is not properly ground, the finished cement will be valueless.

I have found that where this material is coarser than 95 per cent. passing a 100 mesh sieve in mills using pure limestone and low lime-carrying clays, the resulting cement gives very unsatisfactory results. In mills using a high lime-carrying clay much coarser grinding is allowable. But this rule will always apply—the finer the compound is ground, the better the resulting cement will be.

After the compound is mixed and ground, its future treatment depends upon the type of kiln in which it is to be burnt. If any of the forms of upright, or, as they are sometimes called, standing kilns, are to be used, the compound or slurry must be either dried, if the wet method has been used, or dampened, if the dry method was used, to such a consistency as will allow it to be molded into bricks or formed into cakes. The water is then all evaporated, either by the heat of the sun or by some suitable form of drier, in which condition the so-called compound is ready to be loaded into the kilns.

If the rotary system is to be used, the wet slurry or dried compound is ready to be introduced at once into the kiln without further treatment.

The oldest form of kilns in use to-day are the ordinary open or

bottle form. They take the name of bottle kilns from their shape, which somewhat resembles a bottle, narrow at the top and bottom and bulging in the center. These kilns are built in different sizes from 20 to 50 tons capacity, the ones most frequently met with giving about 35 tons per charge. Hard coke is most generally used as a fuel in this class of kilns. Both hard and soft coal have been used, but with indifferent success.

To charge a furnace of this kind a layer of wood is first placed on the grate bars, then a layer of coke or coal; whichever is used, over this a layer of compound which has been formed into bricks or cakes. From this point the furnace is filled with alternate layers of fuel and compound until the working room of the furnace is full. The amount of fuel to be used must be determined by experience, it being impossible to lay down any set rules, as any small change in the composition of the compound makes a difference in the amount of fuel required. The proper loading of kilns of this kind is an art in itself, and is always undertaken by experienced men. All of the kilns of this class will be found to have little peculiarities of their own; a slight difference in draught, for example, sometimes spoiling a whole kiln of cement. In loading kilns of this type great care must be exercised that the draught is not choked or made too free. If it is choked, it will be found impossible to get the required heat; and if it is too free, too much heat will be developed in some places and not enough in others. After firing one of these kilns, it is usual to allow it to burn and cool about 6 days before drawing. The material will be found well burnt near the bottom, lighter burnt toward the top and usually a layer of underburnt on top. The product has to be picked by hand, the well burnt going to the grinding department, the underburnt and lighter burnt returned to the kilns for reburning.

A number of modifications of this kiln have been made in late years, chambers having been added in which to dry the slurry by utilizing the hot gases which escape from the top of the stack. Arrangements have also been made to make a continuous kiln of this class by adding fuel and compound as the charge is burnt and drawn off from the bottom. But experience has taught that it is not an economical process, either in the use of fuel or labor, and it is gradually going out of service.

Another class of kilns, of which the Dietzsch and Schoffer are the only ones in use in this country, employ an arrangement whereby the waste heat is used to bring the dried compound to a red heat before it is drawn into the burning part of the furnace.

They consist of 3 chambers, one over the other, arranged in

such a manner that the lower contains burnt clinker which is cooling; the middle, the compound under process of burning, and the upper, the raw compound which is being heated. Coal is used in this type of kilns as a fuel. The process is continuous and the result obtained very good.

Until about 15 years ago in this country and about 2 years ago in Germany the above class of kilns were the principal ones in use.

In the latter part of the eighties, Mr. F. Ransom brought out a special furnace for calcining cement with gaseous fuel, which consisted of a slowly rotating cylinder lined with fire brick and set at a slight angle from the horizontal. The fuel was introduced at the lower end and the dried slurry in small pieces at the upper end. In consequence of the angle of inclination, the dried material gradually worked its way down to the flame, became clinkered and dropped out of the lower end. The interior of Ransom's furnace was filled with projections of fire brick which carried the material up as the furnace revolved and dropped it through the flame, in this way giving the flame more surface to act upon, consequently producing a more even calcination than when large masses were exposed to the heating agent as in the standing kilns. This kiln was used in England a short time, but was not a success, as, in the first place a lining which would stand the fluxing action of the cement mixture could not be obtained. The cement which was made by this kiln was so abnormally quick setting that it was valueless.

From these experiments of Ransom's, however, the rotary kiln process has developed very rapidly, especially in this country, until now it is used almost universally.

In Europe its introduction has not been so rapid. In 1893 there were only 10 in use, but the success with which they have met is causing a gradual replacement of the old standing kilns. The process as we know it in the United States is almost identical with Ransom's. The kilns consist of a moving cylinder, generally 60 feet long and 72 inches in diameter, set at an inclination of $\frac{1}{2}$ inch to the foot. The upper end extends into a stack base, through which is run a conveying appliance to introduce the raw compound. The lower end is extended into a hood, through which is introduced the fuel, either powdered coal, oil or natural gas. The cylinder is lined throughout its entire length with a heavy basic brick 9 inches thick. Over the cylinder at the rear end, when the dry method is used, a large storage bin for the raw compound is placed. If the wet method is used, tanks are placed back of the furnace for holding the slurry, which is introduced through the rear housing by means of pumps. The kilns are usually driven from a variable speed machine.

This regulator gives the operator full control of the speed of his furnace and the amount of compound which is introduced, and this, with the regulation of his oil, gives him full control of the hardness of the burn. The regulator gives a variation of from 15 to 75 revolutions per hour.

The method of starting a rotary kiln is very simple; a small wood fire is built in the lower end of the cylinder and the fuel turned on. The cylinder is revolved at a very low speed, and the compound, feeding into it at the upper end, gravitates toward the burning zone where the clinkering begins and continues as long as the heat is sufficiently high. The burning zone is about 10 feet from the front of the furnace, and usually has a temperature of about 3000° F.

The clinker as it comes from the standing kiln will always be found to be more or less mixed with over- or underburnt material. This must be carefully separated, usually by hand, before the clinker is ground. From a rotary system, owing to the control which the burner has over his compound and fuel, the resulting product is always well burnt. The consequence is that the cement ground from this process is always higher in tensile strength and more even in color than that from any other system; and, owing to its freedom from underburnt material which always contains free lime, it is more liable to be sound and constant in volume. When the clinker by itself is freshly ground it is usually quick setting. To regulate the setting time the ground cement must either be allowed to age for some length of time or some aging material added to it to hasten the action. The material which is most commonly used is gypsum, either in its crude state or as plaster of Paris.

There are a number of theories explaining the action of this material upon cement, but we are not well enough acquainted with any of them to state which of them is correct. About the only knowledge we have of the action is that we can take a cement which has an initial set of 5 minutes, and, by the addition of a very small percentage of gypsum, less than 2 per cent. of calcium sulphate, increase the initial set to 2 or 3 hours.

The grinding of cement clinker is one of the most important operations in the manufacture. A few years ago 90 per cent. on a 50 mesh and 80 per cent. on a 76 mesh was considered a well-ground cement. At the present time 90 per cent. on a 100 mesh and 75 per cent. on a 200 mesh is thought to give the best results, although some engineers require finer grinding than this, claiming that the finer a cement is ground, the further it will go in work and the stronger concrete it will give. This is true up to a certain point.

A cement can, however, be ground so fine that it will become very quick setting, in which condition it is valueless.

To illustrate this, a sample of cement 1 year old was taken:

Fineness:

100 mesh, 93 per cent. passed.
200 mesh, 74 per cent. passed.
Initial set, 2 hours 35 minutes.
Final set, 5 hours 30 minutes.

A sample of this same cement ground by hand to the fineness:

100 mesh, 98 per cent. passed.
200 mesh, 90 per cent. passed.
Initial set, 1 hour 30 minutes.
Final set, 4 hours.

Another sample of this same cement ground to fineness:

100 mesh, 100 per cent. passed.
200 mesh, 100 per cent. passed.
Initial set, 5 minutes.
Final set, 15 minutes.

This same experiment has been tried on other cement, both foreign and domestic, and in every case the same results have been obtained.

The reason a fine cement sets quicker than a coarser one is found in the Le Chatelier theory for the setting of a cement. According to this theory, the water dissolves out the more soluble parts of the powder, forming a supersaturated solution, which subsequently deposits crystals and gradually forms a solid mass. Obviously, therefore, the finer a cement is ground, the more rapidly the water can act upon the particles and the quicker setting it becomes.

Another factor which plays an important part in the quality of a cement in regard both to the tensile strength and set is the method used in grinding. By this I mean whether the clinker is crushed and screened and the coarser particles recrushed, or whether the cement is all ground fine at one operation. To illustrate this, I have introduced several sets of tests which I had occasion to make a number of years ago in an Eastern mill where several different methods were used for grinding.

The clinker from which the several samples were ground was all taken from the same heap, and was as near uniform as it was possible to obtain:

Experiment No. 1, Ground on under runner millstones and Columbia separator.

Experiment No. 2, Ground on edge runners.

Experiment No. 3, Griffin mills.

Experiment No. 4, Ball and tube mill.

Experiment No. 1, Fineness:

100 mesh, 92 per cent. passed.
200 mesh, 68 per cent. passed.
Initial set, 3 hours 25 minutes.
Final set, 7 hours.
Soundness, not perfect.
Constancy of volume, not constant.

TENSILE STRENGTH.

Neat.	Sand 3, Cement 1.
3 days, 295 pounds.	85 pounds.
7 days, 590 pounds.	185 pounds.
28 days, 680 pounds.	290 pounds.
6 months, 680 pounds.	280 pounds.

Experiment No. 2, Fineness:

100 mesh, 92½ per cent.
200 mesh, 65 per cent.
Initial set, 3 hours 15 minutes.
Final set, 6 hours 30 minutes.
Soundness, not perfect.
Constancy of volume, not constant.

TENSILE STRENGTH.

Neat.	Sand 3, Cement 1.
3 days, 310 pounds.	85 pounds.
7 days, 625 pounds.	195 pounds.
28 days, 715 pounds.	300 pounds.
6 months, 710 pounds.	315 pounds.

Experiment No. 3, Fineness:

100 mesh, 93 per cent.
200 mesh, 74 per cent.
Initial set, 2 hours 25 minutes.
Final set, 5 hours 30 minutes.
Soundness, sound and perfect.
Constancy of volume, constant.

TENSILE STRENGTH.

Neat.	Sand 3, Cement 1.
3 days, 320 pounds.	110 pounds.
7 days, 635 pounds.	225 pounds.
28 days, 740 pounds.	335 pounds.
6 months, 810 pounds.	380 pounds.

Experiment No. 4, Fineness:

100 mesh, 93 per cent.
200 mesh, 75 per cent.
Initial set, 2 hours 15 minutes.
Final set, 5 hours 25 minutes.
Soundness, sound and perfect.
Constancy of volume, constant.

TENSILE STRENGTH.

Neat.	Sand 3, Cement 1.
3 days, 315 pounds.	125 pounds.
7 days, 640 pounds.	230 pounds.
28 days, 725 pounds.	345 pounds.
6 months, 845 pounds.	375 pounds.

Pat tests in cold water on Nos. 1 and 2 were very unsatisfactory, being warped, checked and cracked at the end of 6 months. Nos. 3 and 4 pats were perfect and sound on glass at the end of 1 year. This cement contained 2 per cent. of added gypsum. Under the microscope the particles of the cement from the different mills were as different as it was possible to conceive them. In Nos. 1 and 2 they had every appearance of the original clinker, while in Nos. 3 and 4 an entirely different appearance was observed. The particles had lost their clinker-like appearance and had taken on that of a dark-colored flour. These cements were held about 4 months and again sampled. Practically the same results were obtained as in the first case.

The only conclusion we can draw from the above tests is that the method used in flouring a cement clinker has a very marked influence on the resulting cement.

After the cement is ground and stored in the aging bins there comes from the engineer's or consumer's point of view another very important operation; this is its testing, to determine whether it is fit to go into work.

In Germany, France, and other European countries the Government has taken the testing of Portland cement under its protecting wing and formulated set rules and tests which it must pass before being used. In England and the United States every engineer and consumer has his own ideas about the way a cement should be tested, and as the ideas of these gentlemen usually vary considerably, it is a difficult problem for the manufacturer to formulate rules for testing which will satisfy all of them. The rules which we have adopted at our own works and which are in general use in all the larger mills in this country are those laid down by the German Government. They are slightly modified as to the fineness and soundness tests, but in the main they are the same.

They consist of tests for:

Soundness—freedom from destructive agencies within itself.
Fineness of grinding.
Strength—cohesive and adhesive.
Setting properties.
Weight and specific gravity.
Chemical composition.

The above tests properly carried out will give a fairly good criterion of what the future action of the cement will be.

Care, however, must be taken not to draw erroneous conclusions from any single test or from the whole list of tests at any one time. It is the aggregate of the whole, observed at different periods for a comparatively long time (30 or 60 days), which gives the best results.

SOUNDNESS.

The soundness should always come first in the list of tests. No matter what qualities a cement may possess, such as being finely ground, giving high tensile strength at short periods, etc., if it is not sound it will eventually expand, disintegrate and become absolutely valueless, or worse than valueless, as a binding material. The first method used in determining soundness, and the one which is used as a base for all accelerated tests to-day, is to make a thin pat upon a glass plate, and, after the final set has taken place, to immerse it in cold water (60° to 80° F.). If at the end of 30 or 60 days, or any other longer period, it develops no checks, cracks or alterations from its original form, it is considered sound. There have been a number of accelerated tests proposed and used in different parts of this country to obtain this same end.

Henry Faija subjected a freshly gauged pat to a moist heat of 100° to 105° F. for 6 or 7 hours, or until set, and then immersed it in water at 115° to 120° F. for the rest of the 24 hours. If the pat was firm and solid upon the glass, the soundness was said to be perfect.

Michaelis subjected a pat of set cement to water heated to 212° F. for a period of 2 hours. If at the end of this time the cement was solid and firm upon the glass, the soundness was perfect.

A number of other tests on these same lines have been proposed, and are used with more or less success in different localities.

The fineness of a cement is ascertained by sifting a given weight through a sieve composed of brass wire gauze having a given number of meshes to the square inch. In the United States, sieves of 100 mesh (10,000 mesh per square inch) and No. 200 mesh sieve (40,000 mesh per square inch) are the ones in common use. These sieves are considered standard when the wire is one-half the size of the opening.

For practical purposes it will be found sufficient to take 100 grams, and, after sifting until no further appreciable quantities can be gotten through, the residue is weighed. The weight in grams

will represent the percentage of residue retained by the sieve used. The amount passing the sieve is the one usually reported, *i. e.*, if the cement is said to be 90 per cent. fine, it signifies that 90 per cent. has passed the sieve used, 10 per cent. being retained.

TENSILE STRENGTH.

Too much importance as a usual thing is placed upon the tensile strength of the neat cement. Any of our cement, ordinarily, is strong enough at some period in the time of testing to satisfy almost any specification. It is rather the rate of increase to which the value should be attached. A cement that develops a moderate strength at the end of 7 days and shows an increase of 25 per cent. at 28 days, is better than one showing a comparatively high strength at the end of 7 days and only 5 or 10 per cent. increase at the end of 28 days.

In making briquettes much depends upon the skill of the operator. Each operator has a personal error which should always be taken into consideration when comparing results. The exact rules for making briquettes should be formulated and no variation allowed except where the cement requires them, and these should always be noted in the report upon that cement. Briquettes are usually made in lots of 10 or 20 at a time. The cement is weighed and the amount of water is added which will make a plastic mortar. It must then be thoroughly worked with a trowel until the water is thoroughly incorporated with the cement. The molds are filled either by pressure with the thumbs or by the use of a small rammer and struck off with the trowel.

The sand briquettes, which are much more important than the neat, are made by mixing 3 parts of standard sand and 1 part of cement dry, and then adding from 9 to 10 per cent. water and again mixing. In placing the sand mixture in the molds care must be used to obtain a briquette of a standard weight. If the mixture is rammed too hard, too high a tensile strength will be obtained, and if not rammed hard enough it will be too low. After making, the briquettes are allowed to lie 24 hours in moist air and are then placed in the water (60° to 80° F.) until tested. The results are usually noted at 3 different periods—3, 7 and 28 days. For most purposes this is sufficient, but where great care is necessary, 2 months, 6 months and 1 year are sometimes required.

A number of machines have been patented for the making of briquettes, but they are not very extensively used in the United States.

SETTING PROPERTIES.

The setting properties of a cement are not of great importance unless they are abnormally quick or slow, except for special work. We divide the setting of a cement into 2 periods, called "initial" and "final" set. The period which elapses between the adding of the water and the moment when the mass loses its fluid condition ,is called the time of initial set.

In quick-setting cements this is very distinctly marked, while in slow setting it is so gradual as to be scarcely noticeable.

Final set is the time which a cement takes to acquire sufficient hardness to withstand certain pressure without leaving any indentation.

In determining the initial and final set we use what is called Gilmore needles. They consist of 2 needles, one weighing $\frac{1}{4}$ pound and carrying a wire $\frac{1}{12}$ inch in diameter, the other weighing 1 pound and carrying a wire $\frac{1}{24}$ inch in diameter.

When a cement is mixed to a standard paste (with 25 to 30 per cent. of water) and will carry the $\frac{1}{4}$-pound needle, it is said to have taken its initial set; when it will carry the 1-pound needle, it is said to have taken its final set.

SPECIFIC GRAVITY.

The object of ascertaining the specific gravity of a cement is to enable some opinion to be formed of the amount of calcination to which the sample has been subjected, as the harder the burn the greater the specific gravity will be.

CHEMICAL COMPOSITION.

A first-class Portland cement always has a chemical composition within the following limit:

Oxide of calcium	59 to 65	per cent.
Silica	19 to 25	" "
Oxide of iron	2 to 4	" "
Alumina	5 to 9	" "
Oxide of magnesium	0.5	
Sulfuric anhydride	0.2	
Alkalies	0 to 1	" "

THE COMPARATIVE ECONOMY OF VARIOUS TYPES OF HIGHWAY BRIDGES.

By C. B. Wing, Member of the Technical Society of the Pacific Coast.

[Read before the Spring Meeting of the Society, May 28, 1904.*]

"A road, once accepted and used as a public highway, must be maintained in condition for safe use until legally abandoned. If a highway crosses a stream, and a bridge is built to provide for such crossing, the structure becomes part of the highway, and must likewise be kept in condition at all times for safe reasonable use, and, if worn out or destroyed by accident, must be replaced."†

The cost of a bridge structure is therefore the annual expenditure necessary to perpetually maintain the same in condition for use, and in general that structure should be built for which such annual expenditure will be a minimum.

In some cases, maintaining a bridge at the least annual cost may involve building a type of structure the first cost of which is greater than the present generation can bond itself to construct. Again, the future needs of a district may be uncertain and the building of a temporary structure justifiable. On the other hand, the wealth and æsthetic development of the community may demand a limited expenditure of public funds for artistic and monumental effect.

Disregarding, however, exceptions to the general rule, the following discussion will be confined to outlining methods for determining, in any given case, the type of bridge structure that will cost the least yearly sum for perpetual maintenance.

Considering the building of a bridge as an investment of funds by the community, provision must be made for interest, sinking fund and operating expenses. Therefore the annual cost of perpetually maintaining a bridge may be assumed to be made up of the following items:

a. Interest on capital invested.
b. Sinking fund.
c. Maintenance.
d. Insurance.

That type of bridge will be most economical for which the annual sum of the above items is the least.

The invested capital is the first cost of the completed structure. In determining the annual interest charge, the rate of interest may

* Manuscript received June 30, 1904.—Secretary, Ass'n of Eng. Socs.

† Sec. 2715, "Political Code of California."

be assumed to be the ruling rate for bonds of the community, making due allowance in the case of permanent structures for a decrease in such rate in the course of time.*

If the bridge is built of perishable materials, the whole structure will have to be replaced when worn out. To meet this expense provision must be made for a sinking fund which, in the course of the estimated life of the structure, will create a fund sufficient to replace the same when necessary.

Such bridges also require a constant annual expenditure for maintenance, such as repairing floors, painting, etc.

Another item of annual cost not often taken into account in comparing the cost of permanent bridges with those built of perishable material is that of insurance against accidents to the structure itself or the traffic it carries. A worn-out wooden floor frequently gives rise to a suit for damages, and in time of flood a properly designed masonry bridge is much less likely to be destroyed than one built of wood or steel.†

For the purposes of the present discussion highway bridges may be divided into four types:

Type I.—Wooden bridges.
Type II.—Combination bridges.
Type III.—Steel bridges.
Type IV.—Masonry bridges.

To determine the annual cost of perpetually maintaining bridges of the above types, it is necessary to know their first cost, probable life and cost of maintaining in condition for use.

FIRST COST OF STRUCTURE.

The first cost of structures of the above types for any given location can be best determined by actual designs with estimate of cost. In many cases these designs can be submitted for bids and the comparison of costs made after the bids are opened.

LIFE OF STRUCTURES.

A masonry structure well designed and carefully executed may be considered as permanent in character. One writer has said of masonry: "Its first cost should be its only cost. Though superstructures should decay and drift away, though embankments should

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* Napa County, Cal., bridge bonds bearing 4 per cent. interest recently sold at par.

† The fact that a masonry bridge withstood the Johnstown flood has led many railways to adopt that type of construction wherever practicable.

crumble and wash out, masonry should stand as one great mass of solid rock, firm and enduring."*

The durability of the other types of structures mentioned varies greatly with their location and the care taken to maintain them. The life of the structure as a whole will usually be much greater than that of its parts; thus the floor of an uncovered wooden bridge may have to be renewed four times and the stringers and floor beams twice before it is necessary to renew the trusses.

The life of the structure as a whole can usually best be made the basis of computing the annual contribution to a sinking fund for replacing the structure when worn out.

The cost of renewals of flooring and stringers may then be charged to maintenance.

The following method may be used for computing the annual cost of replacing a structure when worn out.

Let M = cost of structure to be replaced.
n = life of structure in years.
r = annual rate of interest.
A = annual payment to sinking fund.

If the interest is compounded annually,

$$A = \frac{M r}{(1 + r)^n - 1}$$

Thus the first cost of a structure and its probable life being known, the annual cost for sinking fund can be readily determined.

Sixteen, twenty-four and forty years may be taken as average values of the life, respectively, of unprotected wooden, combination and steel highway bridges.

In any given case careful study should be made of conditions of design or location modifying the above values. For instance, a covered wooden bridge may outlast a steel structure, the painting of which has been neglected.† In fact, it will usually be safe to assume in estimating the life of highway bridges that all maintenance charges will be avoided except those absolutely necessary to insure the present safety of traffic.

COST OF MAINTENANCE OF STRUCTURES.

The annual cost of maintaining a structure will vary from a minimum for a masonry bridge to a maximum for an unprotected

* Halsey James, "Railway Masonry and Bridge Foundations," p. 5. Chicago Railway Age Pub. Co., 1883.

† The Y bridge at Zanesville, Ohio, was of the former type and lasted nearly 70 years. *See Engineering News*, 1900 I, 50.

wooden bridge. Except for slight repairs to the roadway, the maintenance charges for a masonry bridge will be zero.

For a well-designed, carefully-covered wooden bridge on dry foundations, the only charges will be for renewing floor plank and painting the exterior. Such a bridge, if not overloaded, should last 70 years.

The maintenance charges for a steel bridge will be floor renewals, cleaning and painting. The cost of these items will vary with every locality. In many locations painting should be done every two to five years to thoroughly protect steel from rust. Yet there are probably few counties in the State that pay much attention to these matters. The result of such neglect will be that the life of many steel structures will be much less than anticipated, and in many cases the life may terminate in a costly accident.

Floor renewals will be the largest maintenance charge with all types of non-permanent structures, and even with exposed Howe or combination Pratt trusses the trusses will outwear from four to six floors and from two to three sets of stringers and floor beams. If the type of floor and its probable durability is determined, the calculation of the annual cost of renewing the same is comparatively simple.

COST OF INSURANCE.

The annual charge to be made to the account of insurance in the case of non-permanent structures is very difficult to determine. A hole in the floor of a bridge may cause the loss of a valuable animal or fire or flood may destroy the whole structure. In the case of many structures not carefully looked after an accident causing loss of life is highly probable in the course of time. The annual charge for such accidents must be accounted for either under this head or by decreasing the estimated life of the structure and thus increasing the annual charge to the sinking fund.

The annual charge for insurance may vary from zero in a locality where structures are cared for and great floods uncommon to a comparatively large sum where these conditions are reversed. The conditions in Pennsylvania, for instance, have been especially severe, and in New Jersey even masonry structures have suffered.

Although it may be impracticable to attempt to give a definite value to the annual charge for insurance in a given case, the fact that one type of structure is less liable to accidents than another must not be lost sight of. If in a given case the items of annual cost other than insurance for a masonry bridge and for a steel bridge are nearly the same, the masonry structure should certainly be adopted.

SUMMARY.

To determine the most economical bridge for a given location, prepare plans for bridges of various types fulfilling the same conditions. Carefully compute the cost of building each type of structure or receive bids for the same.

The annual cost of maintaining bridge structures of masonry will be the interest on their first cost. With all other types of structures, in addition to the interest on the first cost, varying sums should be added for a sinking fund to replace structure when worn out, for maintaining the structure in condition for use and for insurance against accident to the structure or the traffic it carries.

EXAMPLE.

As an example illustrating the method of applying the principles just outlined, the following actual case will be considered:

Data: Roadway crossing a barranca.

Top width of barranca	171 feet.
Bottom width of barranca	30 "
Depth from grade to bottom of water course	45 "

Preliminary estimates:

For a 50-foot arch, 20-foot roadway of stone or concrete with earth fill, side slopes $1\frac{1}{2}$ to 1	$10,800.00
For steel arch, 46-foot span, 20-foot roadway, 4 girders, buckle-plate floor of concrete and asphaltum, stone abutments and earth fill	9,900.00
For a steel trestle, 160 feet long 16-foot roadway, buckle-plate floor of concrete and aphaltum, concrete abutments and piers.	6,259.00
Actual bid on trestle bridge	6,926.50
Estimated annual cost for repairs on steel arch for paint and asphaltum	50.00
Estimated annual cost for repairs on steel trestle for paint and asphaltum	150.00
Engineering and superintendence for either type	350.00

The above are the figures approximately as given by the engineer in charge of the work. That they are approximately correct is shown by the bid on the steel structure. For the purposes of comparison, the total first cost of each may be taken as follows (increasing the estimate ten per cent. and adding the cost of engineering and superintendence):

Stone or concrete arch	$12,230.00
Steel arch	11,240.00
Steel trestle	7,235.00

The annual cost of perpetually maintaining bridges of the above types, with interest at four per cent., assuming the life of the steel structures to be fifty years, would be:

Stone or concrete arch, 20-foot roadway.

Interest on first cost	$489.20

Steel arch, 20-foot roadway.

Interest on first cost	$449.60
Sinking fund to accumulate $3000 in 50 years	19.65
Maintenance	50.00
Total	$519.25

Steel trestle, 16-foot roadway.

Interest on first cost	$289.40
Sinking fund to accumulate $5000 in 50 years	32.75
Maintenance	150.00
Total	$472.15

Giving full value to the permanent portions of the steel structures and making no allowance for insurance, it is seen by the above comparison that the annual cost of the stone structure is approximately equal to that of the steel trestle and that the steel arch is considerably more expensive.

If the steel trestle had been made the same width as the stone arch and steel arch structures, its annual cost would have been greater than for the steel arch. The stone structure is therefore the most economical, and at the same time, if properly constructed, is less liable to accident and deterioration through lack of proper maintenance.

Another example taken from estimates made by the writer:

Bridge, 30-foot span; 20-foot roadway, subjected to heavy wagon traffic.

Assumed life of wooden truss, 16 years.
Assumed life of 4-inch floor plank, 4 years.
Assumed life of stringers and joist, 8 years.

Estimated first cost of a concrete-steel girder bridge, 6-inch reinforced concrete floor covered with 3-inch oiled gravel or earth...$884.00

Estimated cost of King post truss bridge on concrete abutments:

Bridge	$200.00	
Abutments	50.00	
		$250.00

Annual cost of perpetually maintaining bridges of above types:

CONCRETE-STEEL BRIDGE.

Interest on first cost at 4 per cent	$35.36	
Oiling	4.00	
		$39.36

WOODEN BRIDGE.

Interest on first cost at 4 per cent		$10.00
Sinking fund to accumulate $200 in 16 years		9.16
Maintenance—		
Floor plank	$18.00	
Stringers and Floor beams	6.60	
		24.60
Total		$43.76

CONCLUSION.

The writer believes that by a careful study of highway bridge construction, along lines similar to those above outlined, considerable saving can be secured to country communities in the cost of maintaining their bridge structures. This is especially true of irrigated districts that have to maintain a large number of small structures subjected to large traffic. For the eight years from January 1, 1889, to January 1, 1898, the average annual expenditure of one of the interior valley counties of California for bridge work was $22,380.* If this annual expenditure be considered as interest at 4 per cent. on money invested in permanent structures, it would represent an investment of $559,500.

The writer realizes the impracticability of building nothing but permanent structures. Even if bonds are issued the tax on the present generation would be unjustly heavy. He does believe, however, that in many counties by beginning with the smaller culverts and openings as they are worn out, in the course of twenty years the saving to the road fund would be so great that gradually larger temporary structures could be replaced by permanent structures without issuing bonds or materially increasing the road tax.

* "Biennial Report of the California Department of Highways, December, 1898."

THE JET PUMP AS AN HYDRAULIC APPARATUS.

By F. G. Hesse, Member of the Technical Society of the Pacific Coast.

[Read before the Spring Meeting of the Society, May 27, 1904.*]

The following treatise considers the jet pump as an hydraulic apparatus in which the jet and the liquid to be raised are both non-compressible and of the same density.

The apparatus is very simple and inexpensive. It contains no moving parts, no valves, and, like the hydraulic ram, it combines both motor and pump; but unfortunately it has the reputation of possessing a very low efficiency, a quality which has so far been the cause of its very limited application.

It is unfortunate that the writings of prominent men on the subject have a tendency rather to increase than to remove this popular estimate.

Prof. James Thomson, the inventor of the jet pump (see "Report of the British Association, 1852-53"), gives, as results of tests, 18 per cent. as the highest efficiency obtainable, but fails to give the conditions under which the tests were made. We can speak of highest efficiency only for given values of h, h_1 and h_2. See Fig., p. 188. Without such statement the word efficiency has no meaning.

Dr. Gustave Zeuner, in his work on draught produced by a steam jet, gives a general theory of the Thomson pump, concluding with the remark that "its efficiency is always very low, that its application is only available within very narrow limits and that its best feature is its simplicity."

In his work, "Vorlesungen über Theorie der Turbinen," Professor Zeuner says: "It is clear from the last four formulas that the theory of this simple apparatus leads to complicated expressions, which, however, enable us, for any given case (for a given apparatus), to determine its practicability and efficiency. But if we endeavor to find those proportions and dimensions which lead to the highest efficiency, we encounter almost insurmountable difficulties."

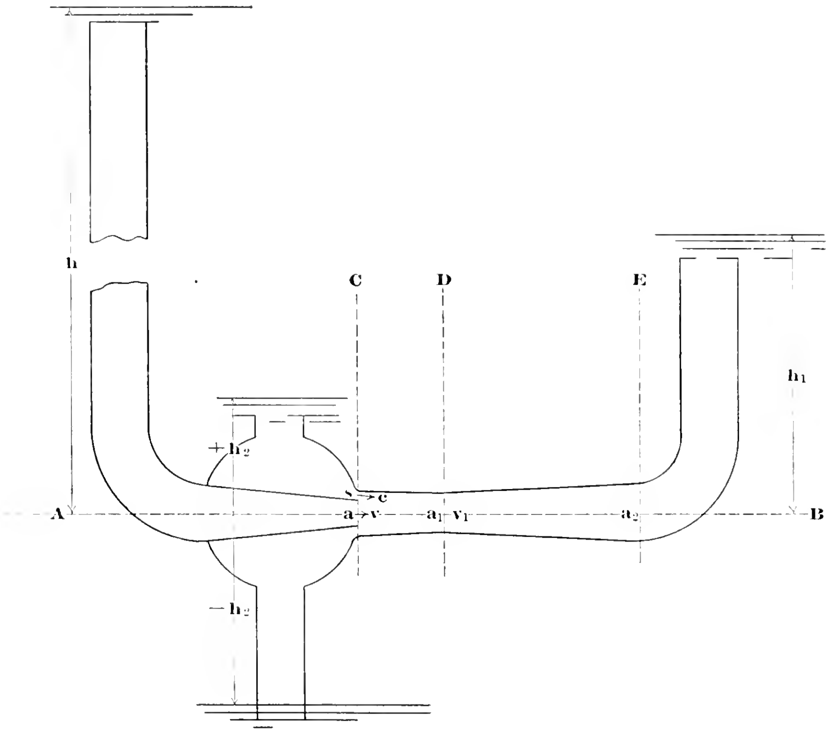
W. T. Macquorn Rankine (see "Proceedings of the Royal Society, No. 123, 1870"), in his paper on the mathematical theory of the combination of any number of jets, applies the principle of conservation of moments to the principal dynamic equation, but only establishes the general fundamental equations. (See *Zeitschrift des Vereins Deutscher Ingenieure,* No. 10, 1866.)

R. R. Werner, professor, Royal Polytechnic Academy in Berlin,

* Manuscript received July 6, 1904.—Secretary, Ass'n of Eng. Socs.

draws attention to an article of Kemp, in Hamburg, published in *Mittheilungen des Gewerbevereins*, in Hanover (1865, No. 2), and then gives a theory of the jet pump, which, in one apparently essential point, differs from all others. (See Note 3.)

Mr. Kemp, in the above quoted article, says: "It is a remarkable fact that the Kemp apparatus still worked well when the suction head exceeded the driving head by 6 to 8 feet, which fact is a convincing proof that the theory of Professor Zeuner can find no application to the Kemp pump." This is true only regarding Professor



Zeuner's treatment without the action of the cone. (See his work, mentioned before, "Vorlesungen," etc., page 68.)

Professor Werner establishes a relation between $\frac{Q_1}{Q}$ and $\frac{C}{v}$, and then says: "For which value of $\frac{C}{v}$ the efficiency is a maximum cannot be determined in general, on account of the intricacy of the above equation, but must be arrived at for each concrete case."

From the foregoing, it is clear that all the writers on the subject have failed to establish formulas for dimensions consistent with highest efficiency.

In the following discussion I consider the stream lines to be parallel with the axis A B, and the loss of energy to be due to impact, in accordance with the well-established law of Cornot.

By far the shortest way is the direct application of the principle of conservation of moments, first applied by Rankine for any number of jets, and by Gustave Zeuner, in his work "Vorlesungen über Theorie der Turbinen"; but, in order to assist the understanding of those who have not paid special attention to the subject, I have based the fundamental equation upon Cornot's principle and shown its identity with that of conservation of moments.

NOTATION USED IN THE FOLLOWING:

A B = datum line.
h = driving head.
h_1 = head to which the water is raised above A B.
$\pm h_2$ = head above or below A B of the water to be raised.
h_0 = head due to atmospheric pressure.
a = area of nozzle through which water is discharged under head h.
s = area of nozzle through which water is discharged under head $\pm h_2$.
a_1 = area of pipe at section D.
a_2 = area of pipe at section E termination of cone.
v = velocity of water through a.
c = velocity of water through s.
v_1 = velocity of water through a_1.
v_2 = velocity of water through a_2.
Q = a v, volume of water discharged through a.
Q_1 = s c, volume of water discharged through s.
$Q + Q_1 = a\,v + s\,c = B_2$.
$a\,v^2 + s\,c^2 = B_1$.
$\frac{p}{\gamma}$ = absolute head at section C.
$\frac{p_1}{\gamma}$ = absolute head at section D.
$\frac{p_2}{\gamma}$ = absolute head at section E.
g = acceleration of gravity.
γ = density of water (weight per cubic foot).

$$B = \frac{p_2}{\gamma} + \frac{v^2}{2g} = h_1 + h_0 + \frac{v_2^2}{2g}$$

ξ_1 = coefficient of resistance to flow of water between C and D.

ξ_2 = coefficient of resistance to flow of water between D and E.

ξ = coefficient of resistance to flow of water through nozzles at C.

η = efficiency.

The energy equation between the limits C and D is:

$$\gamma \frac{a\,v^3 + s\,c^3}{2\,g} + B_2\,\gamma \frac{\rho}{\gamma} = \gamma\,B_2 \left\{ \frac{\rho_1}{\gamma} + \frac{v_1^2}{2\,g}(1 + \xi_1) \right\} + \gamma \frac{c\,s\,(c - v_1)^2}{2\,g}$$
$$\gamma \frac{a\,v\,(v - v_1)^2}{2\,g}$$

$$\frac{a\,v^3 + s\,c^3}{2\,g} + B_2 \frac{\rho}{\gamma} = B_2 \left\{ \frac{\rho_1}{\gamma} + \frac{v_1^2}{2\,g}(1 + \xi_1) \right\}$$
$$\frac{s\,c^3 + s\,c\,v_1^2 - 2\,s\,c^2\,v_1 + a\,v^3 + a\,v\,v_1^2 - 2\,a\,v^2\,v_1}{2\,g}$$

$$\gamma \frac{a\,v^3 + s\,c^3}{2\,g} + B_2\,\gamma \frac{\rho}{\gamma} \quad B_2 \left\{ \frac{\rho_1}{\gamma} + \frac{v_1^2}{2\,g}(1 + \xi_1) \right\} + \frac{(s\,c + a\,v)\,v_1^2}{2\,g} -$$
$$\frac{2\,v_1\,(s\,c^2 + a\,v^2)}{2\,g}$$

$$B_2 \frac{\rho - \rho_1}{\gamma} = B_2 \frac{v_1^2}{2\,g} + B_2 \frac{v_1^2}{2\,g}\,\xi_1 + B_2 \frac{v_1^2}{2\,g} - \frac{2\,v_1\,B_1}{2\,g}$$

I. That is, $\frac{\rho - \rho_1}{\gamma} = \frac{v_1^2}{2\,g}\,\xi_1 + \frac{v_1^2}{g} - \frac{v_1\,B_1}{g\,B_2}$. See Note 1, below.

Energy equation between limits D and E is:

II. $$\frac{\rho_1}{\gamma} + \frac{v_1^2}{2\,g} = B + \frac{v_1^2}{2\,g}\,\xi_2$$

Eliminating $\frac{\rho_1}{\gamma}$ by adding equations I and II, we obtain:

$\frac{\rho}{\gamma} = B + \frac{v_1^2}{2\,g}(1 + \xi_1 + \xi_2) - \frac{v_1\,B_1}{g\,B_2}$, from which follows:

III. $$v_1 = \frac{B_1}{B_2\,(1 + \xi_1 + \xi_2)} - \sqrt{\frac{2\,g\left(\frac{\rho}{\gamma} - B\right)}{1 + \xi_1 + \xi_2} + \left\{\frac{B_1}{B_2\,(1 + \xi_1 + \xi_2)}\right\}^2}$$

NOTE (1).—If we multiply equation I by γ and a_1 and consider that $a_1\,v_1 = B$, we obtain:

$$a_1\,(\rho - \rho_1) = \frac{\gamma\,a_1\,v_1^2}{g} - \left\{ \frac{\gamma\,a\,v^2}{g} + \frac{\gamma\,s\,c^2}{g} \right\}$$

We recognize in this the dynamic equation of motion on the application of the principle of conservation of moments to the fundamental equation referred to before.

It is this equation III which solves the problem.

(1) $\frac{B_1}{B_2}$ is a function of s and increases with s; hence v_1 would increase with s without limit if the sign of the radical was +, which, considering the character of the problem, is absurd. We therefore have to adopt the negative sign for the radical.

(2) v_1 increases with a decrease of the work lost by friction and impact.

(3) For a maximum v_1 the expression under the radical sign must be zero, hence:

$$\frac{2\,g\left(\frac{p}{\gamma} - B\right)}{1 + \xi_1 + \xi_2} + \left(\frac{B_1}{B_2\,(1 + \xi_1 + \xi_2)}\right)^2 = 0$$

$$v_1 = \frac{B_1}{B_2\,(1 + \xi_1 + \xi_2)} \text{ (and see Note 2)}$$

$$v_1 = \sqrt{\frac{2\,g\left(B - \frac{p}{\gamma}\right)}{1 + \xi_1 + \xi_2}}$$

But since $\frac{B_1}{B_2} = \frac{a\,v^2 + s\,c^2}{a\,v + s\,c}$, we have:

IV. $$\sqrt{\frac{2\,g\left(B - \frac{p}{\gamma}\right)}{1 + \xi_1 + \xi_2}} = \frac{a\,v^2 + s\,c^2}{(a\,v + s\,c)\,(1 + \xi_1 + \xi_2)} = v_1$$

NOTE (2).—The maximum value of v_1 can be found in a different way as follows:

The maximum of v_1 corresponds to the least resistance; that is, to a minimum of the work lost. The latter is

$$a\,v\,\frac{(v - v_1)^2}{2\,g} + s\,c\,\frac{(c - v_1)^2}{2\,g} + B_2\,\frac{v_1^2}{2\,g}\,(\xi_1 + \xi_2)$$

Differentiating, etc., we have

$$(a\,v + s\,c)\,v_1 - (a\,v^2 + s\,c^2) + B_2\,(\xi_1 + \xi_2)\,v_1 = 0$$

$$\text{Hence } v_1 = \frac{B_1}{B_2\,(1 + \xi_1 + \xi_2)} \text{ as above.}$$

Solving for s,

V. $$s = \frac{a\,v}{c}\;\frac{v - v_1\,(1 + \xi_1 + \xi_2)}{v_1\,(1 + \xi_1 + \xi_2) - c} \text{ and } \frac{Q_1}{Q} = \frac{v - v_1\,(1 + \xi_1 + \xi_2)}{v_1\,(1 + \xi_1 + \xi_2) - c}$$

Substituting in equation I for $\frac{B_1}{B_2} = v_1\,(1 + \xi_1 + \xi_2)$

we obtain $$\frac{p - p_1}{\gamma} = -\,\frac{v_1^2}{2\,g}\,(\xi_1 + 2\,\xi_2)$$

and neglecting friction, $$\frac{p - p_1}{\gamma} = 0$$

We have also the following relations:

$$v = \sqrt{\frac{2\,g\left(h + h_0 - \frac{p}{\gamma}\right)}{1 + \zeta}}$$

$$c = \sqrt{\frac{2\,g\left(h_2 + h_0 - \frac{p}{\gamma}\right)}{1 + \zeta}} \quad h_2 \text{ either } \pm$$

$$a_1 = \frac{Q + Q_1}{v_1}, \quad a_2 = \frac{Q + Q_1}{v_2}$$

$$\eta = \frac{h_1 - h_2}{h - h_1}\,\frac{Q_1}{Q}$$

The above expressions are based upon an assumed value of $\frac{p}{\gamma}$ between the limits o and $h_0 + h_2$, but it is evident that the highest efficiency is obtained for $\frac{p}{\gamma} = 0$. (See equation IV.)

NOTE (3).—The theory of Professor R. R. Werner is based upon the assumption that the jets of water v and c act by impact upon each other until they flow with uniform velocity v_1. Carnot assumes that the masses issuing with velocities v and c impinge against the whole mass flowing with velocity v_1.

With Werner the work lost is equal to $\frac{(v - c)^2}{2\,g}\,\frac{Q\,Q_1}{Q + Q_1}$.

With Carnot the work lost is equal to $\frac{(v_1 - c)^2}{2\,g}\,Q_1 + \frac{(v - v_1)^2}{2\,g}\,Q$.

It can be shown that both expressions are identical if we substitute for v_1 the value found above; that is, $\frac{B_1}{B_2}$.

It can further be shown more directly that both assumptions lead to the same result, in the following way:

With Werner the common velocity $v_1 = \frac{c\,Q_1 + v\,Q}{Q + Q_1} = \frac{s\,c^2 + a\,v^2}{s\,c + a\,v} = \frac{B_1}{B_3}\,v^1$, neglecting friction.

OBSERVATIONS ON DRIVING PILES WITH A STEAM HAMMER.

By J. J. Welsh, Member of the Technical Society of the Pacific Coast.

[Read before the Spring Meeting of the Society, May 27, 1904.*]

The lot on which this piling was done is the S. E. corner of Spear and Market Streets, San Francisco, and was formerly a part of the Bay which was gradually filled in, the lot therefore being "made ground."

After six piles had been driven, it became evident that the ground was exceedingly soft, and inquiry among architects, engineers and pile-driving firms showed that the ground here was much more yielding than the surrounding area. This may be explained by the manner of filling in. At that time the lot was occupied by houses on stilts and the sand and rubbish were dumped around the stilts, causing the soft mud to rise almost to the same level under the houses without materially compressing it.

The new building was to be of brick and six stories in height, making necessary a careful determination of the actual resistance of the piles. The softest spot was found by driving piles in a number of places. Here a pile and follower were driven down 105 feet without finding a hard stratum. The following day another pile was driven, which sank one foot in the last two blows. On the next day it required 16 blows to sink this pile one foot, the first three blows having no apparent effect, while the fourth blow started it.

It was decided, as a third test, to load four piles. In order to make the conditions such as would exist under a pier, 11 piles were driven into a trench. The four outer ones were left 18 inches higher than the others, so as to bring the bearing only on these four and to give them the benefit arising from the consolidation of the material near them.

The piles were Oregon pine, 70 feet long, and were 12 to 14 inches at the butts and 6 to 8 inches at the point. The test piles were spaced 4 feet 8 inches on centers for the short span, and 7 feet 1 inch for the long span; on top of the four piles were set four steel plates 14 inches by 14 inches by $\frac{7}{8}$ inch thick, and on top of these were placed two 15-inch I-beams, weighing 1000 pounds each, bolted together to each set of piles in the long span, and upon these

* Manuscript received August 2, 1904.—Secretary, Ass'n of Eng. Socs.

were placed eleven I-beams, weighing 1000 pounds each, which formed the platform. On this platform pig iron was piled. Before putting the platform and pig iron on, levels were taken and bench marks made. The pig iron was brought to the grounds in trucks, and each load was weighed on public scales before being delivered.

The accompanying table gives (1) the conditions and results (actual loads and settlements) for each of the four piles, (2) the calculated safe load for each by three well-known formulas, and (3) the extreme load by the Trautwine formula, which is the only one of the three giving extreme load, defined by Trautwine as the load "that will be just at the point of causing more sinking."

The three formulas are:

Sanders:* $$p = \frac{12\,w\,h}{8\,s}$$

Engineering News:† $$p = \frac{2\,w\,h}{s + c}$$

Trautwine:* $$P = \frac{51.52\,w\sqrt[3]{h}}{s + 1}$$

where

P = the extreme load on one pile, in pounds;
p = the safe load on one pile, in pounds;
w = the weight of hammer, in pounds;
h = the fall of hammer, in feet;
s = the final penetration, in inches.

The steam hammer, used with piles Nos. 3 and 4, was known as No. 1, the heaviest made. Total weight 9850 pounds, length 12 feet, diameter of cylinder 13½ inches, normal stroke 42 inches, weight of striking part 5000 pounds, distance between jaws 20 inches, width of jaws 8¼ inches.

The steam hammer used is a gravity hammer, raised by steam, then automatically tripped. When the hammer reaches the pile it automatically opens up the steam, which raises it, consequently the motion is automatic, both up and down.

Now, if we figure the striking part of 5000 pounds as the hammer, we hardly measure the efficiency of the machine, important elements being the constant weight of 9850 pounds (nearly 5 tons) on the pile and the rapidity of the blows.

This machine could strike 65 to 85 blows per minute.

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* Trautwine's Civil Engineer's Pocket Book, Editions of 1902 and 1904, page 592, where the Trautwine formula is given in the form:

$$P = 2240\,\frac{0.023\,w\sqrt[3]{h}}{s + 1}$$

† *Engineering News*, Dec. 29, 1888, p. 511. For drop hammer, $c = 1$. For steam hammer, $c = 0.1$. See *Engineering News*, Nov. 17, 1892, p. 470.

Pile Number.	Type of Hammer.	Number of Blows Struck.	Penetrations* and Falls.	Time of Driving, Minutes.	w, Weight of Hammer, Pounds.	h, Final Fall, Feet.	$\sqrt[3]{h}$	s, Final Penetration,† Inches.	Safe Load, p, in Pounds. Sanders.	Safe Load, p, in Pounds. *Engineering News* Drop.	Safe Load, p, in Pounds. *Engineering News* Steam.	Safe Load, p, in Pounds. Trautwine.‡	First Day's Load, 80 Tons; Total, 44,800 Pounds Per Pile. Settlement, Inches.	Second Day's Load,** 144 Tons; Total, 80,640 Pounds per Pile. Settlement, Inches.	Extreme Load, P, by Trautwine's Formula.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Drop	117	24 inches per blow of 8 feet . . .	15	3,080	12	2.289	6	9,240	10,560	. . .	12,958	1/8	1/8	51,932
2	"	92	72 " first blow, 5 feet . . . 18 " per blow; 9 blows, 5 feet	3	3,080	29	3.072	9	14,887	17,864	. . .	12,187	1/8	1/4	48,748
3	Steam	62	513 " first blow . . . . 24 " per blow, 3 blows . .	2	5,000	3.5	1.518	6	4,375	. . .	5,738	13,966	1/8	3/8	55,864
4	"	120	429 " first blow	3	5,000	3.5	1.518	4	6,562	. . .	8,536	19,552	1/8	1/2	78,208

*See also column 9.
†See also column 4.
‡Trautwine says: "As to the proper load for safety, we think that not more than one-half of the extreme load given by our rule should be taken for piles ***thoroughly*** driven in *firm* soils; nor more than one-sixth when in river mud or marsh; assuming, as we have hitherto done, that their feet do not rest upon rock. If liable to tremors, take only *half* these loads." We here take safe load, p = 1/4 extreme load, P.
** Left on for a little over two weeks. No further settlement.

In *Engineering News* a comparison of the results obtained by steam and drop hammer is given. In this test a steam hammer, weighing 4500 pounds and having a stroke of 42 inches, was used. From 48 to 64 blows, using a follower, were required to drive the pile the last foot. In the same soil and with a pile of the same dimensions, a test was made with a drop hammer weighing 3000 pounds and falling 30 feet. In this case 16 blows were required, using a follower, to drive the pile the last foot. As the ratio of blows without follower to blows with follower is as one to two, the number of blows required to drive these piles the last foot without a follower would have been only one-half as many. Again, in this case, the weight of the machine, being constantly on the pile, is not taken into consideration.

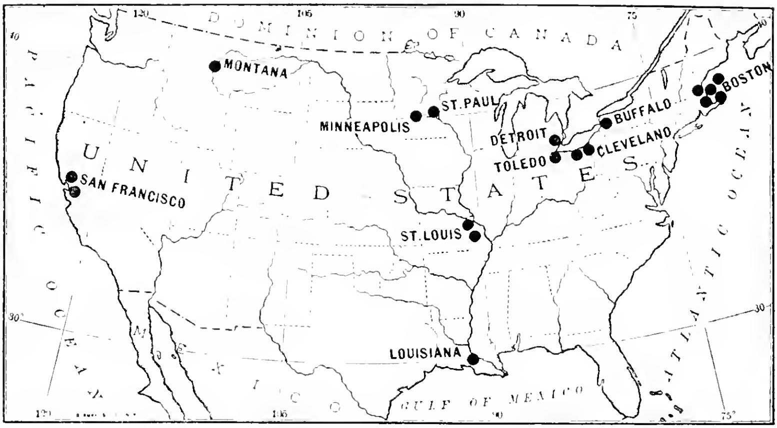
We can readily understand that formulas derived from tests made under different conditions, will vary considerably, and, as the circumstances vary so greatly, it is always well to allow a large margin in calculating the strength of a pile, and a superintendent in charge of the work must depend to a considerable extent upon his own judgment rather than upon results obtained by any of the formulas, and, if any doubt exists, make an actual test.

In conclusion, the results obtained by Wilcoxon & Kearns Co., of Pensacola, from an economical point of view, will be given.

The firm was engaged in the construction of a large wharf and warehouse for the L. and N. Railroad at Pensacola, Fla., which required 7000 piles 60 to 80 feet long. A drop hammer of 4200 pounds was started on a pile which had been half driven with a steam hammer. The hammer had a drop of 60 feet and the pile showed only 1¼ inch penetration to each blow. The live oak cushion block was mashed into pulp. Another pile 75 feet long was driven with the drop hammer without the hood. This took 50 minutes time after it was in the leads, and required 120 blows from the top of the 75-foot leaders. On the next pile of the same length, and 3 feet from the one driven, they used a steam hammer and drove it to the same depth with 130 blows in 90 seconds after it was in the leaders.

This pile had no broomage, while the one along side of it, driven with the drop hammer without a hood, was broomed over three feet. The piles were creosoted, and cost 40 cents per foot net, delivered on the grounds. In using the steam hammer throughout this work, a saving of 21,000 feet of piling was made, at 40 cents per foot, or $8400 total.

Since writing this paper the author has discovered that some of the piles had penetrated through old piles which had been covered up since the filling in. This accounts for the fact that these particular piles could not be driven with the drop hammer, while the steam hammer sent the piles clean through the old piles to the proper depth.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

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THE CLEANING AND FLUSHING OF SEWERS.

Discussion by the Sanitary Section of the Boston Society of Civil Engineers at the Meetings of March 2 and April 13, 1904.*

J. L. WOODFALL.†—Some years ago, engineers believed that all sewers should be laid to a regular or hydraulic grade. It was supposed that any considerable sag in the sewer would cause the solids to collect and plug the sewer. Under the combined system the fear of stoppage was to a great extent well founded, but with the advent of the separate system the danger was to a large extent removed.

Soon after the adoption of the separate system, the question of the pollution of inland waters was taken up in the State of Massachusetts. This was followed by the valuable experiments of the State Board of Health and the building of filtration works for the purification of the sewage of several towns.

Before the question of the pollution of inland waters was taken up by the Legislature of Massachusetts, the problem of the disposal of sewage was, to a large extent, solved by building a sewer or sewers to the nearest water course or large body of water, although in some cases the question of the disposal of the sewage at such a point as to give little trouble was well considered. Under the old method of disposal it was usually a simple problem to build the sewers on proper grades to the nearest point of discharge, but on the introduction of the filtration scheme it was often found that, to deliver sewage onto a proper filtration area, it was necessary to cross some considerable valley.

* Manuscript received August 26, 1904.—Secretary, Ass'n of Eng. Socs.

† Civil Engineer, Boston, Mass.

Naturally, following the old idea that sewers must be laid on the hydraulic grade, the first deduction of the engineer was that the sewage must be delivered, by gravity, to the low point and then pumped to the filtration area, or that embankments or a trestle must be built so that the sewer could be built on the hydraulic grade. I need hardly say that both of these methods are expensive, and in some cases the cost makes them practically prohibitive for small towns. The engineer was thus led to devise some other method to reach a filtration area when separated from the town by a valley. Naturally he adopted the so-called inverted siphon which had long been in use in the distribution of water for domestic purposes.

When I promised our Secretary to read a paper on the inverted siphon I thought it might be possible to give a general history of the subject, but with the small amount of published matter on the subject I found that it would be necessary for me to obtain data from all the engineers who have used this form of construction. Time not admitting of this I am compelled to give a description of the design and construction of inverted siphons which have come under my personal observation with such deductions and suggestions as I deem may be of interest and possible value.

In order to give a clear description of these inverted siphons it is necessary, in each case, to include a short description of the system and the disposal plant.

GARDNER (MASS.) SIPHON, BUILT IN 1890.

The system was designed in 1888 and included about 18½ miles of sewers and the disposal works. One main treatment area and one smaller area were recommended. In this part of the description only the larger area will be considered.

To reach the main disposal area it was necessary to lay the outlet sewer in Conant Street, cross Broadway and the valley of Pond brook,—the lower end of Conant Street and Broadway being at a lower elevation than the filtration area. Three methods for delivering the sewage to the filtration area were available. 1st. Build the outlet sewer in Conant Street as far as possible, then in private land, and cross Broadway at a point where it was higher than the filtration area, then build a bridge over the valley of Pond brook. 2d. Build the outlet sewer to a point near the junction of Conant Street and Broadway, then pump the sewage to the filtration area. 3d. Build the sewer in the lower end of Conant Street and across the valley of Pond brook in the form of an inverted siphon. The third method was adopted.

The outlet sewer in Conant Street is a twelve-inch vitrified pipe laid on a grade of 1 foot to 100 feet. The end of the sewer is 1050 feet from the settling tank which is located at the highest point in the filtration area. At the end of the vitrified pipe sewer a manhole 6.1 feet deep was built. From this manhole to the settling tank an inverted siphon was built. The pipe was laid with from 4 to 4½ feet cover and all joints were leaded. At Pond brook a bridge ten feet long was built to carry the pipe and the pipe was covered with a box. The low point in the siphon is near the brook. At this point a small filter bed was built, a 12 x 8-inch T was inserted in the siphon line and a gate placed at the end of the 8-inch branch. When this gate is opened the sewage, in the inverted siphon, is discharged onto this filter bed. All changes in direction and grade were made gradually with straight pipe until the settling tank was reached. The pipe was laid along one side of the settling tank. After passing the settling tank the pipe was turned at right angles by means of an elbow. It was then carried straight for about twelve feet and then turned upwards by means of an elbow, and then turned into the tank with another elbow, the vertical distance between these last two bends being about three feet.

The settling tank is 15 feet by 20 feet and is separated into two compartments by a 12-inch wall. At one end of the tank a wooden box was built on top of the 12-inch wall. The end of the inverted siphon discharges sewage into this box. Openings from this box to each tank and a swing gate allow the discharge of sewage into either tank. Sewage flows from the other end of the settling tank to a small gate chamber from which it is diverted to the different filter beds. Stop planks near the outlet end of the settling tank retain floating substances. The depth of sewage in the tank is five feet and the water line of the siphon, at its outlet, is about one foot above the surface of the sewage in the settling tank.

Having given a general description of the inverted siphon and a part of the treatment plant I will now give a more detailed description of the inverted siphon and a few remarks as to its working.

The inverted siphon is built with twelve-inch iron pipe. It is 1050 feet long and the low point is 24 feet below the outlet. The outlet is 1.4 feet lower than the beginning of the inverted siphon and the hydraulic grade, using the actual length of pipe as a basis of figuring, is 1.33 feet in 1000 feet.

The inverted siphon was put in operation in the spring of 1891. The blow-off gate was opened several times in the summer of 1891. The blow-off gate was next opened in the summer of 1896. About three or four years ago the blow-off gate was again opened by the

State Board of Health, for experimental purposes. It has not been opened since that time.

The upper end of the inverted siphon is connected with the sewer by means of a manhole. No sump chamber was used.

A considerable amount of sludge was discharged onto the filter bed each time the blow-off gate was opened. No appreciable difference in the amount of sludge was noticeable at the different times this gate was opened. In this inverted siphon the following action has been noticed. For some time after the settling tank had been cleaned, the solids would collect slowly and no scum would appear on the surface of the sewage. The superintendent would notice this fact. On his next visit he would find the surface of the sewage covered with a considerable amount of scum. As I observed this action it seemed to me that the siphon became partly clogged, the head was increased and the accumulated mass of sludge would then be discharged rapidly into the settling tank. Every day a considerable amount of rags and other solids, which do not break up, are discharged into the settling tank. A good example of how an inverted siphon will clean itself was given by the siphon several years ago.

The Superintendent of Streets was macadamizing some streets. After the stone dust had been put on the streets but before it had become solid, stormy weather set in and a considerable amount of dust was washed into the sewers through the open manhole covers. This was followed by a very heavy rain. The stone dust and silt which had been accumulating in the inverted siphon was discharged into the settling tank. When the settling tank was cleaned from 3 to 4 cubic yards of this material was removed. Measurements by the State Board of Health indicate that the average daily flow at this date is 200,000 gallons. The average velocity of flow in the inverted siphon is about 4/10 of a foot per second.

THE ANDOVER (MASS.) INVERTED SIPHON.

The sewerage system for Andover, Mass., was designed in 1894 and contemplated discharging sewage into the Merrimac River. The Andover Sewerage act, passed by the Legislature in 1895, gave the town of Andover authority to build this outlet, but one section of the act, dealing with the possible creation of a nuisance on the shore of the Merrimac River within the town of North Andover, and the abatement of the same, led the Andover Sewer Commissioners to abandon this proposed outlet and adopt the filtration method of disposing of the town's sewage. This resulted in the separation of

the town into a high and a low level area. The sewage from the high level flows to the filtration area by gravity while the sewage from the low-level area is pumped to the high-level sewer at a point near the outskirts of the town. The system, as planned, includes about 21 miles of sewers. The system on these lines was partly constructed in 1898. In order to reach the filtration area it was necessary to cross a valley. This was done by means of an inverted siphon. The outlet sewer is a 15-inch vitrified pipe laid on a grade of 1 foot in 1000 feet.

The inverted siphon was laid in the same general manner as that already described for the Gardner siphon. It had a blow-off gate and filter bed at the low point. It differs from the Gardner siphon of 1890 in the following particulars. The upper end of the siphon started from a screen chamber. This chamber was intended to remove large solid matter. For flushing the inverted siphon a water gate was placed at the head of the inverted siphon. Below this gate a 12-inch by 6-inch Y was inserted and a 6-inch water main, properly gated, was connected with the 6-inch branch. The outlet discharged into a settling tank.

This tank is 50 feet long 8 feet wide and has a circular top. The depth of sewage is 4.5 feet. The sewage flows through the settling tank, passes under a brick wall at the end of the tank, then flows over a brick wall with a stone cap into a dosing tank having a capacity of 5000 gallons. The dosing tank is covered with a brick house. The sewage is discharged from the dosing tank into a gate chamber by means of an 8-inch Miller siphon. From this gate chamber sewage is delivered to the filter beds. The inverted siphon is laid under the end of the settling tank for about 2 feet, it is then turned up by means of an elbow, and the end is at a point $2\frac{1}{2}$ feet below the surface of the sewage in the tank. The inverted siphon is a 12-inch iron pipe 4980 feet long. The low point is 53.5 feet lower than the surface of the sewage in the settling tank. The upper end of the inverted siphon is 12.5 feet higher than the surface of the sewage in the settling tank.

The hydraulic grade, using the total length of pipe as a basis of figuring, is 2.51 feet to 1000 feet.

Measurements made by the State Board of Health show that the average daily flow is about 125,000 gallons, and the velocity of flow in the inverted siphon 25/100 of a foot per second.

I have been informed that the blow-off gate has never been opened in order to flush the inverted siphon, and that it has been flushed but once with water from the six-inch water pipe. I under-

stand that practically all the solids pass through the inverted siphon. No trouble, so far as I am informed, has been given by the inverted siphon.

GARDNER (MASS.) INVERTED SIPHON, BUILT IN 1900.

In 1900 the population in that section of the town requiring a second disposal area, as indicated in the original report, had become so great that sewers and a second filtration plant were built. Legislation was secured by the town which allowed them to take land for sewage disposal outside of the town limits. This legislation made it possible for the town to secure land in the town of Templeton which was satisfactory as a disposal area. In order to reach this area it was necessary to cross the valley of the Otter River. This was done by means of an inverted siphon. The method of construction is similar to that previously described. No blow-off gate was used as the low point is in the bottom of the Otter River. The upper end of the inverted siphon has a gate and a 6-inch water pipe is connected by means of a T.

The complete method of treatment is to first pass the sewage through a settling tank, second through coke strainers and then through sand filters. Experiments made on coke strainers by the State Board of Health indicated the possiblity of treating sewage successfully without the settling tank. In order to see if this could be done the settling tank was not built and the sewage was delivered direct to the coke strainers.

As far as removing solids, it was found that the coke strainers did all that was expected, but it was found that a large amount of sludge was deposited on the surface of the coke. In winter it was practically impossible to remove this sludge. During the winters of 1901 and 1902 the coke strainers were used, but towards spring they were covered with such a depth of sludge as to necessitate putting them out of service and to deliver crude sewage onto the sand filters. Last fall settling tanks were built and connections made with the inverted siphon. For about three months sewage has been running through gate chambers and a by-pass located at the settling tank, but the tanks have not been used as they are not fully completed. In making this connection five elbows were used and a vertical rise of about ten feet. No difference in the working of the inverted siphon has been observed on account of this alteration. With the exception of these elbows changes in line and grade were made with straight pipe until the coke strainers are reached. At this point the pipe is turned up by means of an elbow and then

turned into a chamber with another elbow, the vertical pipe being about seven feet long.

It was considered desirable to deliver the sewage in doses onto the coke strainers. In order to do this the last 427 feet of the outlet sewer was built with thirty-inch vitrified pipe. This pipe together with the twelve-inch outlet sewer, gave a storage capacity of about 2200 cubic feet. The thirty-inch pipe empties into a small chamber in which are located two eight-inch Miller siphons so connected as to work together. These siphons discharge into a second small chamber the outlet of which is the inverted siphon. A twelve-inch by-pass makes it possible to give a steady flow through the inverted siphon. When a steady flow is used a considerable amount of sludge accumulates in the inverted siphon. This sludge is flushed out when the by-pass is closed and the Miller siphons are put in operation. When the Miller siphons are in operation and the 2200 cubic feet of sewage is discharged rapidly to the coke strainers sludge does not accumulate in the inverted siphon. The first discharge in the morning is to all appearances clear water while the following discharges have a considerable amount of solids. This indicates that all solids have been flushed out during the night and in the morning the inverted siphon is filled with practically clear water.

It takes about thirteen minutes to discharge the storage of 2200 cubic feet by means of the two Miller siphons. In the summer of 1901 it was noticed that this time had increased to thirty-seven minutes. Between flows of the Miller siphon the gate at the upper end of the inverted siphon was closed and the inverted siphon was flushed with water from the six-inch water main. The gate on the inverted siphon was then opened and the combined water from the water pipe and the sewage discharged by the Miller siphons were used to flush the inverted siphon. After this flushing the time of discharge of the Miller siphons was reduced to twenty-three minutes. The Miller siphons were kept in operation but no more water was used from the water pipe. A few days after the flushing there was delivered at the coke strainers a mass of rags, combined with an iron rod about one foot long, a piece of large wire about twenty inches long bent in such a way as to be about ten to twelve inches long, an empty quart can and a few smaller pieces of metal. After the inverted siphon had freed itself of this obstruction the time of flow from the Miller siphons was thirteen minutes.

Probably the iron rod and wire were put into the sewer through the holes in the manhole covers. I leave it open for any one to give an explanation as to where the quart can came from. They prob-

ably reached the inverted siphon through the by-pass at the end of the main sewer.

The length of this inverted siphon is 2600 feet and the size 16 inch.

The low point is 32.5 feet lower than the outlet.

The upper end is 5.7 feet higher than the outlet and the hydraulic grade, using the actual length of pipe as a basis of figuring, is 2.2 feet to 1000 feet.

The average daily flow, as measured by the State Board of Health, is 250,000 gallons.

Experiments made by the State Board of Health on the loss of head in the Gardner inverted siphon built in 1890 give the following results:

The inverted siphon was not flushed from July, 1898, until February, 1899. With a flow of 398,000 gallons per day the loss of head, before the inverted siphon was flushed, was 886/1000 of a foot, and with a flow of 422,000 gallons per day a loss of head of 940/1000 of a foot.

After flushing the loss of head was 230/1000 of a foot with a flow of 255,000 gallons per day and 509/1000 of a foot with a flow of 412,000 gallons per day. The theoretical loss of head with the flow of 255,000 gallons per day being 102/1000 of a foot and with a flow of 412,000 gallons per day 263/1000 of a foot. The theoretical head was figured for clear water. This shows that the loss of head after flushing is about twice the theoretical loss of head as figured for clear water and before flushing about three and one-half times the theoretical loss of head.

These experiments indicate that in figuring the size of an inverted siphon to carry sewage a loss of head of, at least, three and one-half times that found for clear water should be used.

WHEN TO USE AN INVERTED SIPHON.

I can give no set rule as to when to use an inverted siphon. I should prefer not to use it if it can be avoided without extra cost or the building of an unsightly structure. When it is necessary or preferable to use this form of construction, I should not hesitate to adopt it, as my experience with the inverted siphons at Andover and Gardner shows that no trouble will be given by them if properly constructed.

ANOTHER FORM OF INVERTED SIPHON.

A number of short inverted siphons have been built which differ in their form of construction from those I have already described. At each end of the inverted siphon is a chamber or man-

hole. The chamber at the upper end of the inverted siphon has a sump and often a sump is built in the chamber at the lower end of the inverted siphon. Usually two pipes are used, and provision is made for cleaning them by building an overflow to a brook. The chamber, at the upper end of the inverted siphon, is divided into two compartments by a wall. A gate in this wall, when closed, prevents sewage from flowing to the inverted siphon and it then flows to the brook through the overflow. It is then possible to pump the sewage from the sump chamber or chambers and the inverted siphon. The inverted siphon can then be cleaned and inspected. A modification of this form of construction is to build chambers in duplicate with a pipe from each chamber. Gates allow the sewage to be diverted to either pipe, so that, while one pipe carries the sewage the other can be cleaned. The good point of this form of inverted siphon is the fact that, not only can it be cleaned out but that it can also be inspected. Its bad points are, first, the collection of sludge at a point from which it is often difficult to remove it, second, the labor necessary to remove this sludge and the probability that it will be neglected. If neglected the sump hole fills up and is of no use. Third, the greater danger of stoppage, this danger being dependent on the neglect to keep the sump chambers cleaned out.

One of the arguments advanced for this form of inverted siphon is that one pipe may be used until such time as the amount of sewage requires the use of the second pipe, thus giving a greater velocity than would be the case if one pipe were used the capacity of which was equal to that of the two pipes. This theory may be all right when the lower end of the pipe has a free outlet but when a sump chamber is used at this point the reduction of velocity will be so great that solids will be deposited and the inverted siphon will soon be plugged unless these solids are removed. The only stoppage of an inverted siphon I have heard of is in one built in this manner.

BEST DESIGN FOR AN INVERTED SIPHON.

I think the best form for an inverted siphon is that used in the Gardner siphon of 1900 but I should place a blow-off at the low point, if possible.

OPEN MANHOLE COVERS.

Open manhole covers provide a means for ventilating the sewers during a greater part of the year, but a large amount of dirt reaches the sewers through the holes in the covers. Many of the stoppages are caused by boys dropping sticks through these holes. One of

the greatest dangers of stoppage, in an inverted siphon, arises from the use of open manhole covers.

When purification works are built the amount of sewage to be treated is unnecessarily increased during storms or the melting of snow if open manhole covers are used.

I consider the objections to the use of open manhole covers, in a system built to carry house drainage only, far outweigh any benefits that may be derived from their use.

Mr. Leonard Metcalf.—I would like to ask the speaker in what way he figures the theoretical loss of head by friction in the siphons referred to, just as a matter of record, as it would make the paper a little more complete.

Mr. Woodfall.—I took a very short method. I obtained the information from Mr. Johnson, of the State Board of Health, who had already worked it out. I refer to Mr. Johnson.

Mr. William S. Johnson.—It was figured the same as for water pipe, assuming that pure water was flowing through the pipes. Weston's tables were used.

Mr. Freeman C. Coffin.—How was the actual loss ascertained?

Mr. Johnson.—A box was constructed at the lower end of the siphon where it discharged into the settling tank, by means of which the level of the sewage was raised sufficiently to make the pipe flow full for its entire length. Hook gages were set up at each end and accurate levels were run between the hook gages.

Mr. Coffin.—The actual difference in the levels of the water was shown?

Mr. Johnson.—Yes.

Mr. W. D. Hubbard.—I would like to ask the speaker whether he ever noticed that grease collected in the iron siphon?

Mr. Woodfall.—I have very often looked at the outlet of the old Gardner siphon, and the pipe, except for a little rust, appeared just the same as it did the day it was put in. Last fall when we broke the siphon which had been in operation since 1901, I looked into the pipes, and those pipes looked exactly like a new water pipe. There was apparently no collection of grease or hard substance in the pipe.

Mr. Hubbard.—Do the drains that lead from the houses have traps?

Mr. Woodfall.—Yes, the house drains are trapped.

Mr. Hubbard.—The reason I speak of it, is that at Concord, when the system was first constructed and connections made with the houses, the old form of placing a 4-inch trap on the house drain inside of the wall was in use in almost all cases, but as soon as we commenced to use the sewer system the cold air from the sewer passing through the trap congealed the grease in the trap, so they had to call for a plumber to have it removed. After a discussion with the Board of Health, the plumbing was changed, and the running trap was discontinued, and the grease now passes out into the street sewers.

We have, at Concord, Massachusetts, two river crossings, which are inverted siphons, and they are operated by storing the flow in a chamber, and discharging it automatically through a Van Vranken automatic tank, and the siphon chamber looked as though it were made of marble. There was a deposit of grease from one and one-half to two inches in depth over the iron-work in the chamber, and I didn't know but that was possibly so in the case of an inverted siphon of considerable length,—that the grease would form on the inside of the pipe. You say it does not?

Mr. Woodfall.—We have never seen it. I would say that, in the new siphon chamber at Gardner, I observed the same thing you indicate, only not to the extent you speak of; grease appears on the walls of the chamber, and of course there is a collection of grease, matches, pieces of paper, etc.

Mr. Hubbard.—I have some notes on the siphons at Concord, which may possibly be of interest.

We have two river crossings where the pipe goes under the bed of the river, forming an inverted siphon, and the flow is regulated by a flushing tank placed in a storage chamber at the upper end of each siphon.

The capacity of the siphon chamber at the first siphon is 7400 gallons, and the fall from the bottom of the chamber to the invert of the sewer on the opposite side of the river is $2\frac{1}{2}$ feet. The siphon is an 8-inch cast-iron pipe, 125 feet long, with a fall of 6 inches from one side of the river to the other. When the sewer was first constructed and nothing was used but clean water, the siphons worked very well indeed, and we had no trouble. As soon as the house connections were made, the flushing tank failed to operate satisfactorily. Instead of operating automatically at intervals, it operated continuously, and we did not seem able to find any method of making it operate in the way it was designed to. There was a tilting pan under the flushing tank, and this pan would fill with an accumulation of grease, rags and sand, and the result was

that it would not work. Our foreman, who was somewhat of a mechanic, drilled a hole in the top of the siphon, and put on an automatic apparatus for breaking its seal. When the water rises in the chamber, it raises an ordinary ball float, which is connected to a lever arm. On the opposite end of the lever arm is a plug which fits into the opening in the siphon leg and closes it. Then, when the siphon begins to operate the ball drops, and by the time the sewage is all discharged from the chamber the ball is in such a position that the lever arm is raised and the plug is released.

The device has worked very satisfactorily indeed. As I said before, we have had grease in the chamber itself, but that is the only place we have had it. It has never troubled us at all in the pipe under the river.

The other siphon is smaller, the capacity of the siphon chamber being 1570 gallons. The length of the siphon is 155 feet, and it is an 8-inch cast-iron pipe with a fall of 6 inches,—the lowest point being 5.72 feet below the invert of the trunk sewer. The water level in the chamber at the time of discharge is 5 feet higher than the level of the trunk sewer. At the end of the discharge it is 2 feet. We had similar trouble with the flushing tank not operating satisfactorily, but it was remedied in the same manner, by drilling a hole in the top of the siphon and putting on an automatic apparatus for breaking its seal.

The sewerage system was built in 1898 and 1899. In the winter of 1902 this siphon chamber was temporarily plugged, the siphon pumped out and inspected, and it was found to be in the same condition that Mr. Woodfall described. In the pipe no silt, grease or deposit was found. It was clean from one end to the other.

In regard to open manhole covers, we have covers that have 37 holes in them, $\frac{3}{4}$ of an inch in diameter, but provision was made to catch any sand that might get in through the holes, or sticks that mischievous boys might put in through them, by means of dust pans made of wrought iron. In order to provide some means of allowing the water to escape, a hole was drilled in the bottom of the dust pan, and the result is that all the finer material passes through that hole and goes down into the sewer. This grit causes excessive wear in the water end of the pump, the linings soon cut through, and in consequence have been renewed three times.

One other point about the open manhole cover. The idea is that they ventilate the sewer. I do not think we have one out of our whole 144 that acts as a ventilator in any manner whatever. The covers, when they were originally set, were placed level with the top of the street. The sewer trenches settled anywhere

from $\frac{1}{2}$ an inch to 3 inches. The street department resurfaced the streets, and in some places they covered the manholes perhaps $\frac{1}{2}$ an inch, so that every team that comes along drives dirt into those perforations and practically blocks them up entirely. Then, again, in winter, all teaming is in the middle of the road, which makes a depressed area between banks of snow, and as soon as the snow melts the water runs through the perforations in the covers, and we see the effect of it in our pumping.

MR. WOODFALL.—I would say that with our Miller siphon the only trouble we have is that at times rags will catch on the rim as they go over. Once in a while we have to clean them out.

As to the tilting-tank, I don't wonder you have trouble with it. In fact I think that it has always given trouble, but the way you have fixed it, probably, has removed all trouble.

MR. FELTON.—I would like to ask Mr. Hubbard whether it is not having the holes in the manhole covers between the knobs that causes them to stop up? I don't believe they would stop up if the holes were in the tops of the knobs.

MR. HUBBARD.—I could not say as to that as I have never tried it.

MR. FELTON.—I think that if you should ventilate through your connections as we do, or have the holes in the tops of the knobs in the manhole covers, there would not be so much difficulty. We ventilate directly through the connections, which very few do.

MR. WOODFALL.—A great many of our manhole covers in Gardner were open. We have taken many of those out and had them cast as solid covers. I think you would find it economy to get the covers cast over and have them solid.

I think if we omit the traps and get ventilation through the roof, we get the most ideal ventilation.

BERTRAM BREWER.*—I am not prepared with an address, but I thought I might say something which would be interesting. In regard to siphons, we have one in Waltham that passes under the Charles River. The outlet of our system is on the south side of the river, and perhaps two-thirds of the sewage comes from the north side. This sewage passes under the river through a 24-inch iron-pipe siphon. It is very much the same kind of a siphon as that described by Mr. Woodfall, with a sump at the lower end.

I will say, in regard to the care of it,—because that seems to be the practical point you are all interested in to-night,—that we have no special difficulty. Whenever we flush the sewer we clean

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* City Engineer, Waltham, Mass.

out the sump, and it is done by a process which has been handed down to me by my predecessor. He connected the manhole over the sump directly with the water main in the street and got up an ejector, which is let down into the sump, and is operated by a jet of water introduced from the water main. The sump is very readily cleaned out, the jet being so strong and the force produced so great that even stones nearly as large as my hand will come out.

Mr. Woodfall.—I would like to ask the gentleman where the material goes to?

Mr. Brewer.—The ejector is introduced at the sump and the material comes up into the street and is cleaned out there. The drop from the street to the bottom of the sump is about 10 or 12, or perhaps 15 feet, and we have no difficulty in keeping the siphon perfectly clean in this way.

Now, a few words in regard to the system of sewers in Waltham and the general method of flushing.

We had a diphtheria epidemic in our town, and the school children were principally affected. Those who know about diphtheria, know that there is no better place to cultivate the disease than within the four walls of a schoolroom; but the Board of Health wanted to find some other cause, so they went around looking at the sewers, and they concluded that the sewers caused the trouble, and thereupon it became necessary to make a very distinct and clear statement as to our method of caring for the sewers, and also, so far as we could, to disprove the erroneous impression that diphtheria germs floated in the air above the manhole covers.

Our system in Waltham consists of about $38\frac{1}{4}$ miles, and over 50 per cent. of it is 6-inch pipe, 25 per cent. is 8-inch pipe, and the rest larger sizes up to a main of 32 inches by 55 inches.

Now, in regard to the manhole covers, perhaps I might speak of that, because we have all had our experience with perforated manhole covers. When our system was introduced, it was very strongly recommended that we introduce a system of tight manhole covers, and the Commissioners discussed the matter pro and con. After they had discussed the matter, they decided that they would have the manhole covers perforated, and they proceeded to spoil every manhole cover in the city. Men went around and bored holes in all the manhole covers, and they bored so many holes and so close together that when a heavy team would go over one of them, it would smash it, and we have had to replace them in a large measure on that account. We tried to stop up the holes, by a mixture of iron filings and sal ammoniac, put into the holes. That lasted for a few years. I also tried the scheme of plugging up the holes by

riveting them, but I have not been able to get the city government to give me money enough to complete the work. For my part, I believe in tight covers.

Our system is ventilated through the roofs of the houses. We have almost no running traps. A few were put in when we started the system.

Now, there is a great difference of opinion about this matter of frequency of flushing. So far as I can find out from all I have read on the subject, some say we should flush as often as every three or four weeks, and some oftener, and some think we should let the sewers go until they fill up and then flush them. It is somewhat a matter of expense. I don't know whether any of you gentlemen live in a city where the tax rate is high and the people are poor, but I do, and they want us to give them good service, that is up to date, and not extremely expensive, so we have struck what we think is a happy medium in regard to flushing. We start early in the spring, just as soon as the ground thaws out sufficiently, and go all over the system and make an inspection. We have pans under the openings of the manhole covers, and those pans are cleaned out, and the manholes cleaned out, and the sewers inspected. In fact we have a sort of spring cleaning day. And after that, during the summer season, we have averaged (during the last four years) flushing five times in the season. And then again, in the fall, just before winter opens, we have another wash day. We go all around and examine the system and clean out the manholes and the pans again. The cost of this work of flushing during the last year—I don't mean the cleaning of the pans, but just the flushing alone—including practically all the incidentals, was $6.56 per mile. That includes labor and the horse and wagon and such repairs as would naturally apply to the business.

In regard to the method of flushing, we have the same scheme which has been adopted in Newton and in Medford. Where the manholes at the summits are a long distance from hydrants, we have introduced direct connections with the water mains and put flap valves on the pipes. Of course, as you all know, we fill the manhole, and lift the flap and flush the sewer. There are about 104 of these flushing manholes in the city. There are many places where we have not been able to get money enough to do that. In places where we could get along with 150 feet of hose, or so, we flush by hand with a hose, and there are 117 of those in our system, so we have in all 221 places where we flush regularly, and this is done by a regular system. We made a flushing map of the city, and the

manholes are numbered in rotation, the object being, of course, to flush in the most effective way from the highest point down.

It may be interesting to say something about the stoppages in our main sewers. I have kept a very careful record of them, especially in the last few years, and I find in 1903 there were 15 stoppages in the main sewers. Eight of them were in 6-inch pipes, 6 in the 8-inch, one in the 10-inch. Of these stoppages 8 were caused by roots from trees. That is our great difficulty in Waltham, roots from trees. One was caused by a brick; two by sticks; one by the ribs of an umbrella; one by paper; one by ice; and one we could not find out the cause of. The average number of stoppages in the main sewers in the last four years in Waltham has been 14.

Mr. Hastings.—I would like to ask Mr. Brewer if in flushing he uses a hydrant, or flushing manhole with a tripping gate?

Mr. Brewer.—We use a $2\frac{1}{2}$-inch hose.

Mr. Barnes.—I would like to inquire as to the time it takes to flush the manholes?

Mr. Brewer.—I think I stated there were 104 of one and 117 of the other. As I recall, I should think it took perhaps a third longer to go around to the manholes than it does with the hose, but, on the other hand, one man can do that, and it takes two or three to do the other and from three and one-half to four days.

Mr. Barnes.—It takes one man to go around to 300 manholes about two weeks, and it takes two men and a cart two days to go around amongst 30, in my experience.

Mr. C. R. Felton.*—We have had so little trouble with our siphons that the subject seems a simple one to us. All our inverted siphons are short. The longest one is only 80 feet, and in every case they consist of two lines of pipe. We have two lines simply to increase the velocity through one, which is all we use during the early years of the system. These siphons are put in without any sumps whatever, running down from the manhole at an angle of 45 degrees, with one-eighth bends. Three of our siphons have never had a stoppage, and they have been in use from 9 to 11 years. In the other two we have had a stoppage on two or three occasions, but in only one side at a time, and the stoppage was easily removed with the rods.

The velocity through these siphons does not usually exceed 0.7 of a foot per second, but it can be increased by flushing to about 9 feet per second. I should say that the velocity would be not more than a foot and a half approximately, except at times of flushing.

* City Engineer, Brockton, Mass.

One of our inverted siphons is 10 inches and 8 inches in diameter, and the others are 16 inches and 12 inches in diameter. With the flushing velocity, which I judge is in the vicinity of 9 feet per second, even large pieces of brick are brought through. With that velocity I was unable to sink a 9-pound iron regulator ball at the outlet end. It would take it right out again. I had, of course, a string attached to it so that I would not lose it.

In our siphons it seems to me that the sump is really not necessary, although I should think it would be a good thing in cases where there is danger of stoppage; but my ten years' experience leads me to believe that they are not necessary under our conditions.

In relation to the flushing of sewers, all our summit manholes are connected directly with the water main, some with a 1-inch and some a 1½-inch pipe, under a pressure of 60 pounds. We flush most of our sewers once a month, some twice a month, and some not so often.

As to stoppages in sewers, they are practically unknown. I don't think we have had in our sewers more than 4 or 5 stoppages in the last 7 or 8 years. We have never had but one stoppage that flowed back into a cellar so that we found it in that way. We have one sewer on a grade of about 1 per cent. that has only been flushed once in 9 years. I don't think if the sewer is laid properly, with a proper grade, and the joints are of the deep socket type, and you don't leave the scraper in, there is much fear of stoppage.

As to stoppages in connections, I should say we averaged four or five in a year. Last year we had only one. We have 1700 connections. The principal cause of the stoppages in connections has been due to plumbers' testing plugs carelessly left in the pipe. We have one connection that stops up with roots, which after they are cut out grow again, and on one occasion a stoppage from grease which entirely plugged up the pipe.

I suppose the question of minimum grade governs largely perhaps the trouble with sewers. I would say that our large egg-shaped sewer, 30 x 45 inches in diameter, has a grade of only one in 1500. Our 8-inch pipe is limited to a grade of one in 200. When we can't get that we take less. We have some perhaps 1 in 300, or possibly 1 in 400. Our connections we put in on a very steep grade, and perhaps that is one reason that we do not have trouble with them. We put them in at a grade of 4 per cent., usually, calling our minimum 2 per cent.

MR. METCALF.—What is the diameter of those connections?

MR. FELTON.—The connections are five inches in diameter.

When you try to connect a 6-inch pipe with a 5-inch Y connection, it causes trouble. We have the Douglas shoe factory, which employs some 2500 persons, connected with a 5-inch connection. Five inches is ample, and I think better than four or six.

MR. BREWER.—How is the connection ventilated?

MR. FELTON.—The ventilation is right through the house. We allow nobody to put in a main trap at the wall, and the connection runs right through to the top of the house. We had considerable difficulty with the United States Government, which insisted on putting a trap on their post-office, but they didn't do it. Their specifications called for it, and as a usual thing they do it. They also wanted to put in a 6-inch connection. We have never had any trouble with this system of ventilation. A great many people think there is danger from it, but I don't think so. I cannot see any need to have holes in the manhole covers where this system is used. Of course the question might be raised as to how the air gets into the sewer. I think the elevation of the houses, in a great many cases of 100 feet, would act as a chimney, so that in certain places air would be going down in the sewers, and other places coming up. I hope somebody will make experiments on that and see where the air goes in and out, and whether it goes in during certain weather conditions and out at other. Perhaps it doesn't ventilate at all.

MR. WOODFALL.—I can say that one experiment showed that with open covers in some manholes the air was going downward through the holes and in others coming out.

MR. FELTON.—I presume that would be so.

MR. W. C. PARMLEY.*—I did not come here with the intention of saying anything, but to hear the rest talk and learn something myself, and so all that I will say is what comes to me on the spur of the moment, but it may be possible for me to bring out some points.

Mr. Felton has spoken entirely of the separate system of sewers. In connection with the sewerage of Cleveland I have to speak of the combined system. The problem of maintenance, of course, is entirely different in a combined system than it is with the separate system. The first serious difficulty which I discovered in Cleveland was in the management of sewer maintenance. The work was in charge of the street department, and the city engineer had no authority. The result was that no attention was given to the sewers until a stoppage occurred and complaint was made, and then when they got time a gang of men would be sent to remove the obstruction. The result was that some sewers would go for years without

* Formerly City Engineer, Cleveland, Ohio.

cleaning, and others, under more fortunate circumstances, would be cleaned oftener. There were upwards of 8000 catch basins at that time, and their chronic condition was that they were filled up to the level of the outflow pipe, and received no attention, except when complete stoppage occurred. Some two or three years ago I undertook to remedy those conditions, and started an agitation along that line. Some of the results of my investigation were published in the JOURNAL of our Society.* The recommendations I made at the time were not all carried out, but most of them were, and they worked very satisfactorily.

The first thing we did was to take the matter entirely out of the street department's hands and place it under the control of the city engineer. We made the sewer department a division of the city engineer's office, and placed in charge an assistant engineer who was a man not only qualified from an engineering standpoint, but also of good executive ability, qualified to manage men, and to keep accounts.

The work was organized with several different gangs of cleaners and inspectors, provided with the necessary tools, wagons, carts and poles, and the city was gone over in a systematic manner. The sewers were first inspected, and where found to be in an unsanitary condition the gang of cleaners began work and followed it down to the outlet. In this way the entire city was covered. When the entire system had been inspected and cleaned the circuit was begun again.

The city is divided into upwards of twenty different sewer districts. The drainage lines do not entirely conform to these districts, as in some cases one sewerage system runs into three or four different sewer districts. Hence one of the first difficulties encountered was in the distribution of the cost of maintenance.

The question was solved in rather an ingenious way. As it happened, some of the sewer districts were not only in a badly dilapidated condition, but verging on bankruptcy, while other sewer districts were just the other way, having at all times a large sewer fund. Sewer district No. 3 was made a clearing house for all the other sewer districts, and all the cost was charged directly to this one sewer district, and once a year the proportional amount chargeable to each sewer district was charged to that district and credited up to district No. 3, which was footing the bill, and in that way it made the accounting system very simple.

A portion of the city is much more sandy than other portions, and in those portions a great deal of cleaning is necessary, espe-

* JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, June, 1900.

cially from the fact that the sewers in many cases have flat grades. Frequently heavy storms wash much sand into the sewers in the districts in which the streets are not all paved. Under these circumstances it has sometimes been necessary to go into the sewers, and with shovels actually shovel out the sand. In other cases, the ordinary methods of flushing have been successful.

One of the most difficult and beneficial acts accomplished by the city has been the transfer of this control of the sewers from the street department,—itself controlled by politics,—to the engineering department, where the benefit of clean sewers is appreciated, and where it is not so much a matter of politics. The result is that the work has been very much better done than it was formerly by the street department cleaners.

Mr. W. D. Hubbard.*—We have in Concord a separate system of sewers, composed almost entirely of vitrified pipe, from six inches to twelve inches in diameter. Our mileage at present is 7.53 miles, and there are 143 manholes. The system has been in operation only four years. We have not had a single case of stoppage so far, in the street sewers, but we have had trouble from tree roots in the streets which are lined with trees.

From what we have been able to discover, if there is a joint in the sewers in which there is a hole as large as a knitting needle, the root will get in, and will grow from ten to fifteen feet long. We remove them with an ordinary wire brush made up of thin strips of flexible steel, which is drawn through the sewers with a ¾-inch Manila rope. This brush tears off the root where it enters from the joint, and brings out the whole accumulation of branches at the manhole. We have tried some of the patented devices for cleaning sewers, but from what little experience we have had, I think the brush gives the best satisfaction.

Our present method is to clean the entire sewer once a year. We use the ordinary Boston rod, the first rod being connected with a ball of iron two inches in diameter, which breaks up and dislodges any ordinary accumulations of rags or silt. At the end (at the manhole) we attach a ¾-inch Manila rope, and on that we put a wire brush, with another small rope attached to it, so that in case we should lose any part of the apparatus we may recover the lost article. We start that way at higher levels and work through to the lowest levels, taking out all accumulations of rags and silt.

The cost for the first year of cleaning the dust pans, which are cleaned once in the spring and once in the fall, and brushing out the entire system of sewers, was $175.50. That included the

* Superintendent of Sewers, Concord, Mass.

time of the men who were actually employed, and the amount that we paid for horse hire, the horse being used to cart around a barrel, in which we put the accumulation, so as not to put it on the surface of the street.

The grades that we have at Concord are, for the 6-inch street sewers, one per cent.; on the 8 and 10-inch sewers, 0.5 of one per cent.; for the 12-inch sewers, .15 of one per cent.

The house connections are all 5-inch, and the minimum grade adopted was about 2 per cent. In one case we had a building that was quite a distance from the street, so that we were obliged to use a flatter grade, say a grade of $1\frac{1}{2}$ per cent., with an angular turn inside a manhole. I watched that connection with particular interest to see just what condition that line would be in, and I would say that that is the cleanest house connection in town. The house connections laid on steep inclines are often fouler than those upon flatter grades, as the liquid runs away and leaves the solids adhering to the interior of the sewer pipe.

The construction of the sewerage system was begun in 1898, stopped in the winter, and resumed again in 1899, and the sewers that were laid in 1898 were used as drains during the construction of parts of the system laid in 1899. The result was that a considerable amount of sand accumulated in some of the lines. We had one 8-inch line which was filled with sand for a distance of 580 feet, and the problem was how to get rid of the sand. We tried scrapers attached to the Boston rod, and they operated very well up to a distance of 25 or 30 feet from the manhole, but after we got in 50 or 60 feet, the scraper would simply run up hard against the sand and stay there, and when we pulled it back we wouldn't have anything to show for our trouble. So we ran the rods through the entire distance between manholes, carried a rope through, put a chain about 3 feet long in the middle of the rope, tied knots in the chain, turned a hydrant stream into the upper manhole and pulled the rope back and forth, dragging the chain over the sand. The only result we got from that was to distribute the sand over twice the distance. Then we put a plug in the lower manhole and repeated the operation, using an Edson pump to pump out the sand and water. That brought it out, but it looked as though it was an everlasting job to get the sewer cleaned that way, hence the next step was to get an ordinary piece of stove pipe, somewhat smaller than the sewer, and $2\frac{1}{2}$ feet long, and put a plug in one end in such a manner that there was a space of about a quarter of an inch around it, in order that any water in the pipe would run through and leave the sand. We attached this pipe to the rope and pulled

it as far as we could, and then pulled it back bringing some of the sand with it. In this way we cleared the sewer. Since then we haven't had any trouble with sand. More or less sifts through the covers, but as I previously said, we have dust pans under the covers that retain all save the finest.

In the house connections we have possibly three or four stoppages a year, and they seem to be principally caused by newspaper and coarse wrapping paper, which lodges in the pipe.

We had some little experience with patent scrapers intended to be attached to the Boston rod, but it was very disastrous. The first time we attempted to use them was in 1900. We had everything going smoothly until we got into a section of sewer work in which the manholes were 375 feet apart. The scraper stuck somewhere and the rods broke, and we had a scraper and about 100 feet of rods left in the sewer. We made numerous attempts to get the rods out and dislodge the scraper, without any effect, and finally the sewer had to be uncovered and a hole cut in the pipe. The scraper has stayed out ever since.

In regard to the flushing, the dead ends of the system are provided with automatic flushing tanks that contain 320 gallons, the intention being to operate them once a day. From what I have noticed in regard to these flushing tanks, I can only say that they are effective for perhaps 500 feet. If you pass two manhole distances the friction in the sewer reduces the flow or velocity so that the water from the flushing tank does not run over an inch or two inches deep.

On the high levels where there is no flushing tank, we simply take a plug made of sheet rubber, backed with canvas, and packed between two circular pieces of wood about half an inch less diameter than the pipe, and push it right into the pipe. We fill the manhole from the nearest hydrant, pull out the plug and let a charge of water from the manhole go down. This we do twice a year, spring and fall, and we have never had any complaints from odors, either from house connections or from the street manholes.

After hearing the gentleman from Waltham mention the cost of cleaning, I am a little loth to say what the cost is at Concord, though the small mileage of sewers tends to increase the rate. Its average for the past three years has been from $20 to $25 a mile a year. With the present methods the lines are kept free from roots, the liability of stoppage reduced to a minimum, and I do not think it would be of advantage to reduce the cost very much and then have stoppages which would cost more than we save.

I might add that after having the Manila rope break two

or three times we bought a piece of what is known as "tiller" rope; this is made of a number of fine strands of wire inclosing a hard core. It was very strong and very flexible, but we found that unless the men are very careful to keep it from touching the ends of the pipes at the manholes, the sawing back and forth, when the brush is in motion, will cut through the pipe in very short order. Then, again, the small wires are apt to break, and when they break, the rope becomes rather awkward to handle and cuts the men's hands.

MR. DANA LIBBY.*—As most of you probably know, the city of Newton covers a large area, its greatest length from north to south being $4\frac{1}{2}$ miles and its greatest width $4\frac{1}{4}$ miles. It is composed of fifteen villages, of which the part known as Newton Corner is the nearest to Boston,—seven miles from the South Station.

Owing to the fact that the population covers so large an area, long trunk lines and many miles of small pipe sewers laid on minimum grades are necessary and the maintenance expense is necessarily larger than in most cities of the same population.

Newton has what is known as a separate system, consequently most of the sewers are small. The first contract was let in the spring of 1891, and we have at present 96 miles of sewers, 80 miles of which are 8-inch pipe; 8-inch is practically the minimum size, 6-inch having been laid only in a very few short streets where the rate of fall was large. The minimum grade used here for 8-inch pipe is 0.50 per 100 feet. The sizes used for house connections are 5-inch and 6-inch, with a minimum rate of 2 feet per 100 feet. The trunk lines are 24 inches by 36 inches and 20 inches by 30 inches, egg-shaped.

Underdrains have been laid under the sewers in all cases where ground water was known to stand near sewer grade. This gives a dry foundation on which to lay the sewer, and assists in taking water from damp cellars.

Two men with a three-wheeled push-cart attend to the flushing of the sewers through the year, covering the whole system in from four to five weeks. Flushing-manholes with a $1\frac{1}{2}$-inch connection to the water main are built at the summits and ends of lines. Rubber-bound wooden plugs are made of the right size to fit the outlet. When the outlets have been plugged, the manhole is filled with water and the plug is drawn. This sudden flush of water is usually sufficient to clean a line throughout its entire length. If, however, any solids are found farther down the line, a second manhole is filled from the same flusher and the operation is repeated.

* Deputy Street Commissioner in charge of Sewers, Newton, Mass.

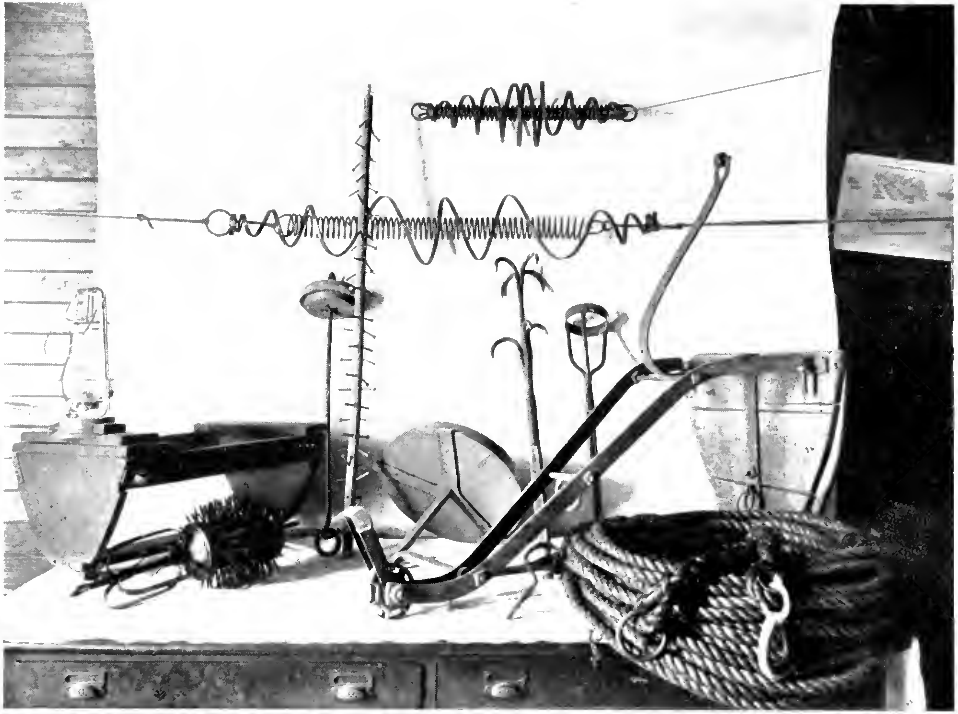
The flushing gang are instructed to begin at the outlet and follow up the line, taking off each cover as they go. If the line is found to be clean, the flushing is omitted. This flushing gang also attends to the numerous stoppages which occur on house connections, as well as to the ordinary flushing and cleaning. During the winter months, when the sewer construction gangs are not busy, an additional force is employed in cleaning places that need immediate attention, these places having been determined beforehand by mirror inspection.

The streets of Newton are lined with shade trees, and their roots readily follow down through the less compact earth in the sewer trench and find defective joints if any exist. The underdrains become clogged with these roots much more frequently than the sewers, as they are laid with open joints, but the number of stoppages in sewer pipe, due to an accumulation of roots, has been far greater than was ever anticipated. Our maintenance appropriation for one year is not large enough to enable us to dig up and relay these bad places, and for a long time we have been trying different kinds of apparatus with which to successfully remove these roots. On the accompanying print will be seen the sewer cleaning implements in use in Newton. The spring-cutter shown on the upper part of the sheet has been in use only two seasons, but has proved to be a very effective root-cutter. Two positions are shown to better illustrate its use. This cutter is made of the best American spring steel, $\frac{1}{4}$ inch thick, and about $\frac{3}{4}$ inch wide, with the outer edge sharp like a knife. The ends of the spring being small, are easily pulled into a bunch of roots; and the cutting action, caused by pulling the spring backward and forward, is sufficient to loosen a very compact mass. This device has also been found to be useful in removing grease and silt which collects on the bottom and sides of sewer pipe.

For the last two years, the city of Newton has used only the deep-socket pipe in three-foot lengths for sewers, and we consider this one of the wisest steps taken for securing tight joints.

Up to the present time we have found no especial difficulty in the maintenance of iron inverted siphons. The 6-inch and 8-inch double inverted siphon under the Charles River at Newton Upper Falls, which the city built in 1901, has given no trouble worthy of mention. We have three other 6-inch inverted siphons in the city which are usually cleaned every winter, but have been allowed to go two years without causing any trouble.

The large trunk lines are kept free from deposits by a system of



SEWER-CLEANING IMPLEMENTS IN USE IN NEWTON, MASS.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, Vol. XXXIII, No. 4, October, 1904.

To face page 222.

hand cleaning and the use of the car and scraper on the print. This work costs about $80 per mile.

The total cost of flushing and cleaning pipe sewers in Newton for the year 1903 was $1791.67 or $19.08 per mile.

MR. E. S. DORR.*—Mr. President and gentlemen: I doubt whether I can offer you anything that is of any value. The city of Boston has no separate system of sewers. Nearly all of our sewers take street water through catch basins, and our difficulties of maintenance come from that source. Most of our stoppages in sewers are caused by gravel and sand being carried over from the catch basins into the sewers. This of course would not happen if the catch basins could be kept clean down below the trap, as they should be. It unfortunately happens that the sewer department has had an insufficient amount of maintenance money now for many years, and the condition of the catch basins and of the sewers is quite similar to that in Cleveland described by Mr. Parmley.

In flushing sewers we use, almost altogether, the fire hose connected with a hydrant. In old times we had some flushing manholes constructed at the upper termini, which were filled with water and emptied as has been described by the other speakers, but that is very seldom done now. There are no flushing tanks in use in the city of Boston. When flushing proves insufficient, we resort to cleaning by scrapers. We have the ordinary outfit of jointed rods and hoe scrapers. The rods we use are the rods which screw together with threaded couplings. There is another form on the market with the toggle-joint, but I advise you to beware of it, because it lacks the rigidity of the rod which screws together, and it is also impossible to do with it what can be done with the other. When the hoe scraper catches, as Mr. Hubbard has mentioned, it is almost always in a defective joint. With the screw connected rods, the rods are turned in the right direction, so as not to unscrew them, and almost always the scraper can be turned on its back and thus released.

We find almost all kinds of material in the sewers. In some sewers the material packs down very hard indeed, and for these sewers we have in the last three or four years made considerable use of a patented device, of which, with your permission, I will proceed to show you a model.

This first came to our notice when we had a sewer in East Boston which was almost stopped up with the East Boston hard pan. Our foreman was entirely unable to remove it with the ordinary scrapers, but a man named Healy made his appearance and asked for a chance to try it. We gave him the opportunity, and he pro-

* Chief Engineer, sewer department, Boston, Mass.

ceeded to put his machine to work, and he cleaned the sewer. Since that time we have given him other difficult sewers to clean, and, as a matter of fact, it has become almost a practice to delegate to Mr. Healy sewers which are pretty difficult to clean. The machine is essentially a shovel or scoop carried on a truck and supported on three wheels. It is sometimes used in connection with a jointed rod or a rope can be attached to each end, and it is then worked by winches from the manholes at each end of the stretch which is being cleaned. That device has proved very effective. The illustration shows the manner of pulling the device back and forth by means of winches. I think the peculiar advantage of that is in the rope, by which the operator is enabled to trip the scoop, in case it catches, and in that way free it.

The Chairman.—How small a sewer will that work in?

Mr. Dorr.—That will work in a 12-inch sewer. There are various sizes.

The Chairman.—How large?

Mr. Dorr.—I think he said they had them for four-foot sewers.

The Chairman.—Different sizes?

Mr. Dorr.—Different sizes. In brick sewers, I know he sometimes runs through a small one, when the sewer is nearly full, and then follows it with a larger one. This particular job in East Boston which he first undertook cost 17½ cents per running foot. The material was packed down almost to the hardness of concrete, so that shortly before that we had to take up and relay a 12-inch sewer.

While I am on that subject I might mention the fact that we have had considerable trouble in Boston from marble and glass dust from factories where those materials are worked. In one case we compelled the parties to put in a catch basin, the essential feature of which is that the outlet is placed at a higher elevation than the inlet, so that if the catch basin is not kept clean it disconnects itself so that it must be kept clean.

Now, in regard to siphons, of course what I have to say applies both to siphons on combined sewers, and on intercepting sewers. The largest siphon the city has is in Dorchester Bay. That is a 7½-foot brick siphon and dips down about 160 feet and comes across Dorchester Bay to Squantum. No difficulty has been experienced in maintaining this sewer except from accumulations of grease in the shaft at the outlet end of the siphon, and that is rather an annoyance than anything else.

That has amounted to as much as 25 cubic yards per month. At the present time it is taken care of by a party who clarifies and makes some use of it. I don't know what, I have never inquired.

But we give him the grease if he will keep the shaft clear, and that has been a very good bargain. We guard, of course, very carefully against letting any heavy deposits go into this sewer by running the sewage through two deposit sewers. The sewage is passed through one of these sewers at a slight velocity so that settlement may take place, and when several feet of this has collected, the sewage is run into the other one, and the first one is cleaned. These sewers are 16 feet wide and about 1600 feet long. It is quite a task to move this mass of material down to the lower end from which it is removed, and two crude devices, which may be of interest, have been used. One is floated on a pontoon, from which depends a vertical diaphragm like a large barn door. The sewage supports the pontoon, and running underneath the diaphragm, which nearly fits the sewer, carries along the sludge.

THE CHAIRMAN.—That is a float in the chamber?

MR. DORR.—That is a float in the chamber. A rather more effective device is shown here. This is a submerged raft with a vertical diaphragm standing on it. It is a little more effective, but stirs up the material more than the first one, so this one is usually in the inlet end, the upper part of the deposit sewer, and then the one depending from the pontoon is used on the end next to the shaft, so as to create less disturbance, and causes that material to be carried over into the shaft. When this matter is moved, to a point near the west shaft where the tunnel begins, it is taken hold of by a conveyor, so-called, which is a kind of rough elevator pocket arrangement which scrapes the material along to the outlet of the pipe, when it is flushed down into a tank and deposited from the tank into scows and taken to sea.

I have another blue print here showing the detail of a siphon of the Dorchester intercepting sewer. Very little difficulty is encountered on siphons in intercepting sewers for the reason that the flow is large and very fairly uniform, and they keep themselves clean. In this manner there has been no trouble whatever, except a slight accumulation of grease, which is taken care of by the same individual who takes care of the other.

But the siphon on a combined sewer, which receives the flow of many catch basins, is a very different proposition. I have here a blue print of a very small form, and I offer it as a good example of a bad design. That siphon is situated on Tremont Street, at the foot of Calumet Street, at the foot of a very steep hill, and it has been the source of great trouble on account of the impossibility of keeping it free from deposits of sand and gravel. It has to be cleaned out, and it has to be visited at regular intervals lest

it may become stopped in the meantime. The deposit, of course, occurs at the time of low flow, and is not noticed until a storm comes along, and then the siphon is found to be insufficient in size, and backing up and flooding result.

There are some other siphons in the Boston system, of which I don't happen to have the plans. We have a very troublesome one on Hanover Street, caused by the putting of the subway down Washington Street. The peculiarity of this siphon was that it became plugged with grease from the hotel district drained by the Hanover Street sewer, and we finally adopted a system of having this inspected once a week and cleaned out once every two weeks, and that is the only way in which we could keep that clean. That has now been happily relieved by the building of a deep sewer, which drains off the lower end of it, and practically removes the siphon. But that was the system which we had to adopt.

The best form of siphon which I know for a combined sewer is the kind we have to-day. It is a double-pipe siphon. The ordinary dry flow being conducted through the smaller of the two pipes, and the larger one being available for carrying the storm flow. I have here two blue prints showing the details of such construction. Several of these have been built, particularly in Brighton, and they give almost no trouble. They practically keep themselves clean, the velocity in the small pipes being sufficient to keep them cleaned, and no flow occurring in the large pipes, except at the time of storms. A cleaning of once a year is sufficient for them. That is all that occurs to me to say on this subject.

Mr. F. Herbert Snow.*—The difference of cost of operating and maintaining a properly designed and constructed separate sewer system, and one not so designed and constructed, is illustrated by a comparison of the figures which have been given to-night with those which are about to be offered.

The data for the latter were collected in a city outside of Massachusetts, in which there are over 40 miles of separate sewers and as many more miles of house connections. About one-half of the sewers and connections are said to have been laid within the past ten years, and about all of them were constructed in a desultory manner, regardless of a comprehensive plan. The name of the city is withheld pending the submission of a report to the authorities on the subject.

In this city over $4000 was expended during the last year in scooping out sand and removing stoppages from the sewers. To facilitate comparison, the expense may be divided into three classes:

* Civil Engineer, Boston, Mass.

1st. Inside stoppages—those on private property.

2d. Stoppages in connections—outside of private property.

3d. Those in street mains.

The cost of the inside stoppages is assumed by the private owner.

The last two divisions pertain to the expense of maintaining the public system.

Considering now ordinary stoppages only, we have the following items of cost for the year, for each division:

Inside stoppages	$145
Connections	596
Mains	1,063
	$1,802

The $145 represents the money expended by the public office in locating stoppages which were reported to be in the house connections in the street but which, upon inspection, were found to be actually on the inside of the property and the subsequent removal of which therefore had to be attended to by the owner at his own cost. No record is kept of this private cost, but it is known to be large. The number of inside stoppages unreported is also known to be large, in fact, several times greater than the number reported.

During the year, in the street mains and connections, there were 482 ordinary stoppages and 134 more on private property, making a grand total of 616 stoppages chargeable to the operating account of the sewer system.

In analyzing the causes of these stoppages it was found that

Grease	caused	19	stoppages in	mains and	8	in outside	connections.
Sand	"	25	"	"	26	"	"
Rags	"	83	"	"	47	"	"
Breaks	"	16	"	"	21	"	"
Misc.	"	79	"	"	128	"	"

The 222 stoppages in the mains, cost $1063, or $4.79 per stoppage.

The 260 stoppages in the outside connections, cost $594, or $2.28 per stoppage.

The total cost of each one of the above causes according to the classification in the table was as follows: grease $189, sand $208, rags $444, breaks $139, miscellaneous $677.

But most of the miscellaneous stoppages were caused by the accumulation of grease between the street line and the sewer main, and about one-half of the inside stoppages originated from this source. So also grease materially increased the cost of scooping

out the sewers. In view of these facts $1200 is estimated to be the annual expense of handling the grease trouble, but this represents only the money paid out for the removal of grease from the public sewers and connections. The annual sum paid out by individual owners for inside grease stoppages is estimated to be not less than $3500, which represents an investment at 4 per cent. of $87,000 or about ten dollars for each connection in the city. While this is a large sum, it would require over $200,000 in the aggregate to install a proper grease trap in every building connected with the sewer system.

The inconvenience and unhealthfulness of frequent stoppages is, however, a matter of serious importance and demands some remedy. About 300 stoppages annually are attributable to grease. These might be prevented by the installation of proper apparatus on every property.

The cost of handling the sand for the year was as follows:

In inside connections	$75
In outside connections	121
In mains	227
	$423
Scooping in mains	741
Total	$1,164

The sand enters through defective joints and broken pipe and through house connections. Quite frequently it comes from the inside property and runs out through the connection and fills the street sewer.

In conclusion it seems fitting to observe that only a very brief comment on these figures is called for.

The annual cost of operating and maintaining the separate system in most cities does not begin to approach anywhere near the above amounts, and as would be expected the excessive cost in this case is due to abnormal local conditions, which, it may be added with emphasis, might have been avoided and no doubt would have been had the present state of affairs been foreseen or anticipated.

The various items cited are so great as to forcibly illustrate the economy of devoting attention to the design and construction of house connections as well as to the sewers themselves.

In fact, the sewer system begins in the house and if a division is made between the public sewers and the individual house connections whereby care is exercised in laying out and building the former, and the latter are allowed to be laid and maintained without such care, the whole sewer system may be rendered inefficient and unsanitary.

MR. W. D. HUNTER.*—Melrose is situated seven miles north of Boston, on the Western Division of the Boston and Maine Railroad, and has a population of about 14,000 people, located in three settlements,—Wyoming, Melrose and Melrose Highlands.

The sewer system, which is a separate one, serves about 13,000 people, comprises 35 miles of pipes varying in size from 6 to 24 inches, and cost $390,000. In its construction, every effort was made and no expense spared to make it as efficient and lasting as possible. All pipes used were of a special design, deep and wide sockets, molded in 3-foot lengths, and selected with great care in regard to regularity of form, smoothness and glazing; all joints were made and all brick work laid with Portland cement mortar; manholes were located at all junctions, all changes in either line or grade, and at intermediate points 250 feet apart, although in a few instances the distance between is 300 feet. The work was begun in 1894, and practically completed in 1898, although each year since then minor extensions have been made.

Melrose is situated in a valley, surrounded by hills, and consequently many of our sewers are constructed on a flat grade, and nearly all are below the ground water of the territory; fully two-thirds of them required underdrains which were for temporary purposes only. Underdrains with permanent outlets were tried and found unsatisfactory.

The sewers constructed during the years 1894 and 1895 were provided with automatic flushing tanks located at all summits, connected with the water mains, and the flow so regulated that they would dump once a day or as often as required. Upon trial it was found that the benefit from these tanks was purely local and did not extend more than 300 or 500 feet; consequently their use was discontinued.

All house connections are 5 inches in diameter, laid by the city accurately to line and grade; and where angles are unavoidable, manholes are required. The connection with the house plumbing is made through a Y, and the opening directly in the line of the pipe provided with a screw-cap, which can be removed for flushing or cleaning. The Board of Health require the use of the running trap, but if the householder desires to omit it, he can do so by having his plumbing made to stand the water test. Few have done this, therefore it cannot be said that our system ventilates entirely through the houses, although it does so to some extent, but principally through the manhole covers, each of which is perforated with four

* Engineer and Superintendent Public Works, Melrose, Mass.

$\frac{3}{4}$-inch holes. This is apparently satisfactory, as we have had no complaint nor been visited by an epidemic of any sort; in fact, Melrose is one of the healthiest places in the Commonwealth.

In regard to flushing or cleaning, I hardly think that flushing is the proper word to use for the work done by us in cleaning our sewers, as we rarely use water other than that flowing in the sewers.

I have read the papers presented at the last meeting, and find that the method of cleaning in Melrose differs from that used in any other place mentioned, and I presume this is largely due to the different conditions that appear to exist.

Most of the papers refer to trouble or bother by stoppages from tree roots; although the streets of Melrose are lined with trees to such an extent that from a distance it has the appearance of a forest, this complaint is practically unknown to us. We have had only two stoppages from roots, one in a main pipe and one in a house connection, each of which was readily removed, as the root which entered the joint, and which connected the growth inside the sewer with the main root outside, was very small, not more than 1/16 of an inch in diameter, and broke easily when hooked onto. The accumulation of grease is prevented by the use of extra large "pot traps," located at the inlet of each fixture; these traps also act as grease traps.

The method pursued in cleaning the sewers is to scrape out any deposit that may have lodged in the inverts. We start at the summit and flush or clean all laterals to the main and then clean the mains, and so on, sweeping everything down to the sump where our local sewer connects with the Metropolitan sewer, and where any deposit can be readily removed. The cleaning or scraping is done by a steel hoe made the shape of the pipe with a joint or hinge, so that in pushing it backwards it partly collapses or shuts up. Back of this hoe is what we call a follower, which consists of a bag or bundle of bags, made into a roll two or three feet long and wound with a small rope so as to entirely fill the smaller pipes, and is drawn through after the hoe; this also stops the flow of water, and when the hoe is pulled out into the manhole the deposit is taken up in pails, carried to the surface and put into cesspool barrels. When the follower is pulled through into the manhole, there is a rush of sewage or water which sweeps them clean.

This method is of course much more expensive than the ordinary use of a hydrant hose, which we also use in some places. The same process is followed in the larger pipes, except that the bag or follower does not entirely fill the sewer, perhaps only two-thirds, and is kept on the bottom by being weighted or filled with sand.

We use the so-called Boston rod, extra heavy castings fitted with oak rod 1½ inches in diameter and 3½ feet long, made especially for us, and have never had any trouble with their breaking or coming apart.

Our cleaning is done once a year, usually in the winter, when the men employed would otherwise be idle.

The cost of flushing or cleaning a system of sewers depends largely upon its situation and method of construction. We have no siphons; all of our sewers have a continuous grade from summits to outlet, and cost us yearly to clean about $600, or $17 per mile, including labor, teams and all incidental expense.

Mr. T. Howard Barnes.—I would suggest, Mr. Chairman, that there should be a statement incorporated with this paper describing the flushing tanks in use in Melrose. I think it is misleading that they should be described as flushing tanks. As a matter of fact, they are tilting tanks holding about 50 gallons each and not the siphon tanks which discharge 200 or 300 gallons.

Mr. Berry.—I should like to inquire if the result would not be just the same with the siphon tank. In Laconia, N. H., we use siphon tanks and my experience has been that although our tanks hold 150 gallons, we do not get any different results from those in Melrose. If better results are obtained anywhere, I would like to know it.

Mr. Harrison P. Eddy.*—The sewer system of Worcester comprises 169.13 miles of sewers, 6380 manholes and 2630 catch basins. About 450 house connections are made annually. There are now 68.9 miles of sewers for sewage only, 61.64 miles of combined sewers and 38.66 miles of surface water drains. For nearly twenty-five years the sewers have been built by day's labor, about 130 miles having been constructed in this way. At the present time the minimum wage is $1.85 per day of eight hours.

The following table gives the number of miles of sewers, the total cost and cost per mile of maintaining the same for each year from 1877 to 1903 inclusive. The lowest cost per mile reached in any year was $110.47 for 1898. During the last few years a number of automatic storm gates and pumping stations have been added to the system, and these have materially increased the cost of maintenance:

* Superintendent of Sewers, Worcester, Mass.

COST OF MAINTAINING AND SIZE OF SEWER SYSTEM.

Date.	Miles of Sewers.	Net Expense	Cost per Mile.
1877	36.17	$7,775.44	$214.97
1878	37.26	6,567.59	176.26
1879	37.38	6,307.16	168.73
1880	37.88	6,937.43	183.14
1881	40.40	6,379.10	157.90
1882	42.90	7,490.01	174.59
1883	45.63	8,421.88	184.56
1884	48.00	9,132.05	190.25
1885	50.94	8,656.86	169.94
1886	56.41	10,843.23	192.22
1887	62.89	12,819.53	203.84
1888	68.02	12,989.12	190.96
1889	71.39	13,995.65	196.04
1890	76.59	14,686.38	191.75
1891	80.94	13,435.66	165.99
1892	85.44	13,488.24	157.86
1893	90.04	15,423.38	171.29
1894	95.42	16,302.97	170.85
1895	99.29	17,518.17	176.43
1896	102.69	15,925.38	155.08
1897	112.01	14,504.06	129.48
1898	121.97	13,475.08	110.47
1899	134.14	16.234.00	121.02
1900	151.09	19,488.55	128.98
1901	158.47	19,730.69	124.50
1902	162.75	22,715.75	139.57
1903	169.13	26,300.89	155.51

During 1903 the entire cost of cleaning sewers was $9018.92 or $53.32 per mile. This includes the cost of a large amount of scraping, pail and boat work on sewers receiving storm water.

The cost of cleaning catch basins during 1903 was $8414.03, which amounts to $3.232 per catch basin per year. From these basins about 20,653 cubic yards of refuse were removed and hauled to the public dumps at a cost of $0.407 per cubic yard. This cost includes the entire expense of this branch of the work such as inspection, office expenses, thawing frozen traps and various incidentals but does not include repairs upon the basins themselves.

There are several methods of flushing in use, although all new work is provided with water pipes in the end manholes. There are several automatic flush tanks in use, although it requires as much care to keep them in good order as it does to flush from the pipes in the manholes, and so far as can be seen no better results are obtained. A large portion of the system is flushed at intervals of five

weeks with 2½-inch fire hose attached to hydrants. This is a very expensive and clumsy method and has the decided disadvantage of not being practical in the winter, it not being deemed wise to open the hydrants for this purpose between the first of December and the first of April.

The minimum size of pipe used for public sewers is eight inches in diameter, and some of it is laid at a grade of 1 in 400, and no trouble is experienced with it. In fact in the last twelve years there have not been six complete stoppages in the sewer system and one of these was in a twenty-inch pipe. There has not been a single stoppage due to roots of trees, although there are many streets which are lined with old elms. Systematic inspections of the entire system are made twice each year and frequent inspections are made of certain doubtful lines of pipe. The entire maintenance department is in the hands of one man, who has no other duties than to see to it that no one complains of a failure to operate, either of a sewer or a catch basin. How this is to be accomplished is up to him to find out.

Eternal vigilance is the price of clean sewers.

Worcester is situated among hills, and there are many streets which have considerable grade with a resulting large quantity of detritus washed from them by every rain. Much of this finds its way into the sewers, although every inlet is provided with a catch basin. It is interesting in connection with a study of the problems of maintenance and cleaning to consider the reasons for these deposits.

The solid matter reaching the sewer will be carried along by the water and the pipe left clean provided there is sufficient current. Dubuat has shown that the velocity required varies for matters of different sizes; *e. g.,* 0.4 feet per second will move fine clay, while 2.5 feet per second will be required for fairly coarse gravel. It is obvious also that it will take a higher velocity to start an obstacle than to keep it moving.

It is generally considered wise to provide a grade sufficient to cause a velocity of 2.5 feet per second, when flowing full, although a great many sewers receiving storm water have been built on flatter grades. It is not enough, however, to provide a certain mean velocity and assume that there will be no deposit. At all points below half full the mean velocity will not be reached. From the following table it will be seen that the mean velocity in a 15-inch circular pipe laid at a grade of about 3.5 feet per 1000 feet is very low for depths up to five or six inches. It frequently happens that a storm will not reach an intensity sufficient to more than one-third fill the sewers. It also frequently happens that a certain part of the

shed intended to be served by the sewer in question is not developed, and for this reason the sewer does not receive even in storms of high intensity sufficient water to fill it more than say one-third full. Under these conditions and especially the latter it is easy to see why it is that there are deposits in the sewers even though they be laid at a grade which would give a velocity of 2.5 feet per second when running full.

MEAN VELOCITY AND DISCHARGE OF 15-INCH SEWER.

Depth of Water, Inches.	Coefficient of Roughness, 0.015. Mean Velocity, Feet per Second.	Slope, 0.0035346 Discharge, Cubic Feet per Second.
1	0.60	0.021
2	1.05	0.102
3	1.43	0.250
4	1.74	0.457
5	2.02	0.723
6	2.25	1.031
7	2.45	1.375
8	2.61	1.737
9	2.74	2.106
10	2.84	2.468
11	2.91	2.807
12	2.94	3.094
13	2.93	3.311
14	2.85	3.397
15	2.53	3.105

In general the statements made regarding the storm sewers are applicable to the sewers for sewage only. There is, however, a difference in the matter carried in the water. In sewage the solids are largely of an organic nature and are nearer the specific gravity of the water in which they are carried. If deposits occur there is at once a fermentation started which disintegrates the larger solids until they reach a size easily carried along. If this decomposition goes far enough there will be gases formed which will actually lift this matter to the surface of the water when it is readily washed onward.

Following is a table in which the interesting features of two lines of surface water sewers are presented. In different portions of each sewer trouble is caused by deposits forming.

Street.	Location.	Kind.	Size, Inches.	Length, Feet.	Grade per 1000 Feet.	Velocity, Feet per Second.	Shape.	
Pink	John to Highland	Surface	24x36	81.2	0.95	2.06	Egg	Deposit occurs.
"	"	"	18	132.9	0.99	1.47	"	"
"	"	"	"	112.0	0.97	1.46	"	"
"	"	"	"	106.1	0.62	1.17	"	"
"	"	"	"	131.8	3.69	2.86	"	"
"	"	"	"	114.0	0.58	1.13	"	"
"	"	"	"	117.25	2.08	2.14	"	"
Highland	Pink to Schussler Rd.	"	"	21.0	6.33	3.74	"	No Deposit
"	"	"	"	183.0	4.12	3.02	"	"
"	"	"	12	165.6	4.07	2.26	Rd.	"
North	Grove to Milton	Combined	22x33	453.5	1.00	1.99	Egg	Deposit occurs.
"	Milton to Prescott	"	18	125.5	1.70	1.94	"	No Deposit
"	"	"	"	125.3	2.29	2.25	"	"
"	"	"	"	125.0	1.34	1.72	"	"
"	"	"	"	118.9	3.08	2.61	"	"
"	"	"	15	127.6	4.18	2.56	"	"
"	"	"	"	125.0	1.51	1.54	"	"
"	"	"	12	125.3	17.08	4.63	Rd.	"
"	"	"	"	125.4	38.80	6.97	"	"

In this table the figures are given beginning at the lower end of the sewer and proceeding up the line. It will be noticed that there is no trouble with the Pink and Highland Street sewer at the upper end nor until a point is reached at which the velocity falls to 2.14 feet per second. There is one short section of this sewer where the velocity should be 2.86 feet per second and where trouble is experienced, but it will be noticed that there are very flat sections on each end of this one which doubtless have an effect upon the steeper portion.

It is interesting to notice that there is no trouble with the North Street sewer until the lower end is reached where for a distance of about 450 feet the velocity falls to 1.99 feet per second. This velocity is considerably higher than that of several sections above, where it falls as low as 1.54 feet per second in one case. It should be noticed, however, that each of these flat sections is preceded by at least one section which has a good velocity. It therefore seems reasonable to assume that the velocity resulting from the steeper grades has an effect upon the short sections immediately below and in this way the detritus is carried by the short, flat portions.

These tables and conclusions are of course very incomplete and of a tentative nature, but it would seem that further study along

these lines might result in the accumulation of information which would prove of value.

THE CHAIRMAN.—I would like to ask Mr. Eddy what his flattest grades are on separate sewers?

MR. EDDY.—We have flat sections on sewers of about every size, but I would not dare to tell from memory what the flattest grades are.

THE CHAIRMAN.—In Cambridge we have a number of sewers laid on very flat grades both in the combined and in the separate systems. One trunk line of combined sewer, of sizes 4 to 8 inches in diameter and about 6000 feet long, is laid on a grade of .033 per cent. or 1 in 3000. This sewer, laid nearly 30 years ago, has required but little cleaning, although subject to tidal action which checks the flow twice a day, and would naturally cause a deposit of street washings, etc.

In 1895, a separate sewer was built, 1950 feet long, 24 inches in diameter, on a grade of .06 per cent. or 1 in 1666. Included in this was an inverted siphon 130 feet long under a canal.

In addition, about 3900 feet of sewer 25 x 29 inches in dimensions were built on a grade of .08 per cent. or 1 in 1250. Neither of these sewers has been cleaned, although the flow at times is very small. The sump at the siphon filled to a certain point, and has since remained with the same amount of deposit in it.

While it is desirable to lay sewers, especially laterals, with a good grade or inclination, my experience would indicate that extremely flat grades are not only permissible but practicable—the latter requiring simply more careful watching and more frequent flushing.

MR. GEORGE A. WETHERBEE.*—Mr. Brewer has related almost exactly our experience in Malden. We have about 47 miles of sewer, ranging from 6 inches in diameter to three feet. In regard to the flatter grades, quite a number of the sewers are from one in 450 to one in 500. A 15-inch sewer has a grade of one in 750; an 8-inch sewer, one in 900, and the 2-foot sewer, one in 1500. On the 15-inch line we have an inverted siphon, which we clean out once a year, and there is not very much in there then.

We have one 8-inch pipe in Edgeworth with a grade of one in 500. We take care of that at the annual cleaning in the winter and again in the summer. I think once or twice we have had to flush it in September and then again in June; but the other 8-inch sewers in that district have a grade of about one in 300, and we have had no difficulty with them. The cost of cleaning is a little less than

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* City Engineer, Malden, Mass.

$5 per mile each year. We may have to pay more for it after a while.

About 2 years ago the State took a portion of our larger sewer in order to take care of some of the Everett sewers, and I don't think they have touched that sewer since they took it. It doesn't look as if they had.

THE CHAIRMAN.—How large is that sewer?

MR. WETHERBEE.—It is a three-foot sewer. About 3 years ago, we started to clean that as usual in the winter, and found the entire length of it, some 700 feet, covered with a thick crust or scum, so thick that if you dropped a rod upon it, it would bounce back. So we started to clean it by flushing at each of the manholes. I fitted the manholes with curbs so as to put in boards, and in the bottom one was an orifice, a little less than the diameter of the sewer, closed with a slide. The manhole was filled with sewage and flushed perhaps 20 times, and in the first manhole, 500 feet below, we did not notice any movement of the grease. I then borrowed from Mr. Barnes a jumbo—a series of rubber discs, 8 or 10 inches in diameter, and managed to get my rods and ropes through the manholes, and pulled that through without starting it at all. It was pretty cold weather, and we gave it up, thinking we would wait until warmer weather and then finish it. In the meantime I had prepared some wooden balls, a little less than the size of the sewer, and took them down about the first of June, and opened up the sewer and found about 5½ inches of water. The scum and everything else had gone. That stuff which was so thick and looked like a piece of carpet had during that time all disappeared.

In the small sewers I have the head of every line connected with the water pipes, by a 1½-inch service, and these manholes are filled at the annual cleaning. I have a tin form that I put into the sewer and when the manhole is full I pull the cover out of that, and in that way I flush the sewer. We have no flushing tanks, and I thought I would wait until I found somebody who would demonstrate the advantage of them. We never used a great deal of water. We have never had any roots in our sewer and never had but one stoppage, and that was in a 6-inch pipe on a grade, I think, of about 9 or 10 per cent.

In the house connections we have had one stoppage from roots, and I had at that time a chisel or a gouge made to cut the roots out. Since that time, we have never had any trouble from this source. When we first started putting in the house connections, the city contracted with some of the sewer layers to do the work and at that time we had one stoppage. One of the inspectors allowed the sewer

to be laid up to a rock about 5 or 6 feet in diameter, and instead of removing the rock he began on the other side. We found that out a little later and removed the rock.

I was pleased to hear Mr. Brewer say it cost so little to clean the sewer in Waltham. It does not cost me more than $5 a mile.

I think a good deal depends on the way sewers are laid in the first place. Ours were laid very carefully, and sometimes I think they may have been laid extravagantly. They are all as straight as a gun barrel and they are as clean as a new gun barrel when you look through them. I think that is really the secret of success.

Mr. Eddy was speaking of the grades of sewers. We have a great many flat ones, and I do not know why we don't have more trouble, but we certainly get along very well with a grade of one in 500. I have made plans for what we call the Linden district, and a great many of my 8-inch pipes have been projected by necessity, with grades of one in 800 and even one in 1100. I don't know whether we will have any trouble or not. I consulted several engineers about putting in a small pumping plant, on account of the flat grades which would otherwise be necessary, but I let it go at that.

The 8-inch sewer with a grade of one in 500, has been cleaned three times in a year, but generally it has been cleaned only twice a year. It is not really bad at any time, that is, no one has complained of it.

We do not ventilate through the houses. They seem to have objections to that in Malden.

The Chairman.—Do you have open manhole covers in Malden?

Mr. Wetherbee.—We have open covers at present, but we shall not have if the Board of Aldermen let me stay there long enough. I have closed a great many with oak plugs. Some of the oak plugs have been in there five years. I shall put on tight covers eventually. I have experimented a good deal with the ventilation, and I find that, in a great many of the low sections the current goes downward through the holes in the manhole. The only complaint of odor we have had was from a manhole at the head of a small sewer. A plug had been left in there and there had never been any connection made with the sewer, so it was perfectly tight. Some of the neighbors complained of an odor, but the manhole was as dry as a bone; there had never been any connection made with the sewer.

Mr. Wetherbee.—We have three inverted siphons at brook crossings and have never had any trouble with them. We have two manholes, one on each side of the brook. The one on the lower

side is sunk perhaps three and a half or four feet below the line of the sewer. That fills up with sand, and I presume in the year we get out two-thirds of the cubic contents of the sump. Of course through some of the low lines we have to scrape a little, but not very much. We have just about finished now.

Mr. A. C. Townsend.*—Mr. Chairman, I did not expect to be called upon this evening, and I did not prepare myself to make any remarks.

We have a very fair sewer system in Lynn. It was started along in the early 70's, and the original sewers were laid with practically no engineering. As some of the men who have cleaned them out have said, "They look as though they had been laid by a blind man with a broken-down level." So I don't think I had better make any comments about the grades of those sewers. Practically all the trouble we have with the care of sewers, or our maintenance work, is that connected with the old sewers. The new sewers which have been built within the last twelve or fifteen years give us practically no trouble, but the grades of those sewers are about one in 300 or 400. The worst thing that I ever got up against, as the boys say, was cleaning the sewers where there was a soap factory that lost a tank of soap into the sewer. We had a 36-inch brick sewer, with a very slight grade. It seems that there was some sediment of sand, etc., in the sewer. The soap factory, when the soap was boiling, lost the contents of this tank, and the whole tank full of soap got away into the sewer. It was cold weather, and a few days afterwards we had a complaint that the lateral sewer pipe was stopped up. I sent the man who had charge of the maintenance up there, and he looked it over, and he said, "I don't know what to say; it is as hard as a rock." That is all I could get out of him. We tried all kinds of hoes and scrapers, and we found the main sewer was so bad for 300 or 400 feet that we actually had to put a man in with a rubber suit on, on his hand and knees to chop into it. We finally pulled out one chunk, one piece of soap, that was longer than I am tall, and about as thick through as I am. I think that is the worst thing the Lynn sewer system ever had. Altogether we took out three or four tip cart loads of hard soap.

The water was cold in the sewer, so that just as soon as this hot stuff struck it, it stiffened up, and it completely filled up the sewer connection.

In our general maintenance and flushing of sewers we use mostly the hydrant hose in the manholes, and we find it is fairly satisfactory, pushing the sediment through the small pipes into the

* Superintendent of Sewers, Lynn, Mass.

main sewers and there taking it up by buckets. In very large sewers, six-foot sewers, we use boats. As I say, the sewers built in the last fifteen or twenty years have given us practically no trouble. We have given them a good inspection frequently, and it averages just about every three months that the inspector makes a tour of the city. If he finds something wrong on the old sewers we have considerable trouble. We have 30 or 35 sections that we flush at least every month, no matter whether winter or summer.

In regard to roots, we have had very little trouble. We had one or two cases where we thought there were roots, and ran our rods and hooks in and found that the roots were just started, and we caught onto those and pulled them out all at once.

I am sorry that I did not know that I was to be called upon, because if I had I would have made a little story which perhaps would have been of interest to you.

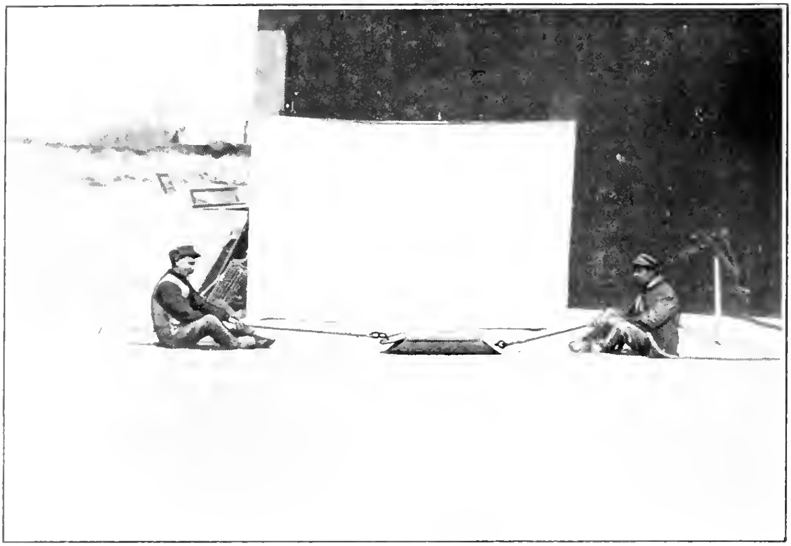
The Chairman.—Have you any idea, Mr. Townsend, how much money you spend on maintenance?

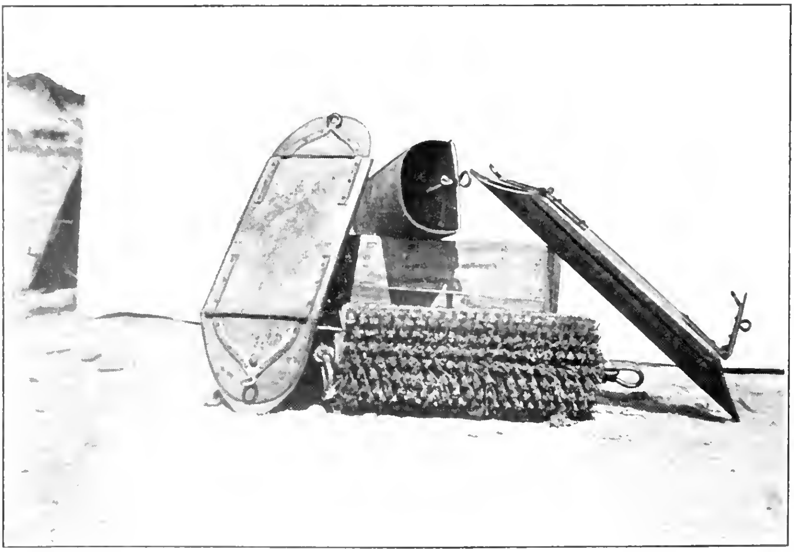
Mr. Townsend.—Well, I cannot give the figures on that, for this reason: Our catch basin cleaning and sewer cleaning is done under one head, and until recently we never had a satisfactory method of keeping books, so we could not tell exactly what our maintenance was. In the last three years we have started on cleaning out some main sewers that have not been touched for perhaps a dozen years, and that has increased the cost.

We have about 75 miles of sewers, and we have $10,000 appropriation every year for the care and maintenance of sewers, and with that money we have to clean out our catch basins and make our repairs to the sewers and our repairs to the catch basins, etc. We always have money enough to go around, so it is not very expensive, but at the end of this year I shall probably be able to give figures on the cost.

Mr. E. W. Branch.*—We have in our system about 40 miles of sewers, all built on the separate system, and at the start we had a pumping station, but the Commonwealth has taken our pumping station, so the money we spend for maintenance is for flushing and cleaning of sewers. The annual appropriation is $1500. The cleaning of the sewers is under the direction of the Board of Public Works, and I only know by observation about the details of the work. They flush about once in six weeks, from the flushing manholes at the summits. I think we have about 125 of these flushing manholes; we do not have automatic flushers, but turn on the water when we want to flush. We find that flushing every six weeks or

* Engineer Sewerage Commissioners, Quincy, Mass.





two months keeps the sewers in good condition. Most of the sewers have been scraped once in the last two or three years. There has been quite an accumulation of a sort of fungus growth, and that they take out with a rattan brush, which works very successfully, and the flushing, as I say, keeps the sewers very well cleaned. There are some places where the sand has got in through the ventilating manhole covers, and we were obliged to scrape the sand out. We have devised a scoop which I have not seen anywhere else, which worked very successfully.

In regard to grades, we get the best grade we can, and we started in on our 8-inch pipe with nothing flatter than a foot in 200; but I think we have one place where there are 700 feet of 8-inch pipe laid with a foot in 400, and we have had no trouble there. The maintenance men tell me that they see no difference in taking care of that, and that there is no greater accumulation of solid matter there. On the larger sewers we started in to get nothing less than one in a thousand, but in the last year we laid some 8000 feet of 20-inch pipe one in 1800. I suppose the cost of maintenance will be increased there, because more flushing will be necessary.

The Chairman.—What has been your experience with the sewer having a grade of one in a thousand; has that been troublesome?

Mr. Branch.—The most of the cleaning of these sewers has been on account of this growth that I spoke of; it seems to be something that accumulates.

The Chairman.—Above the water line?

Mr. Branch.—In the water. It clings to the sides of the sewer and in some places there remains only a narrow channel for the water in the center.

The Chairman.—Can you tell us about the scoop?

Mr. Branch.—The idea originated with me. I had something like a double-ended sugar scoop, with partition in the middle, made from sheet iron. A rope was attached to each end, and it was pulled through the sewer from manhole to manhole. If there was too much sand for it to be pulled the whole distance at once, it was pulled back to the manhole from which it started; the design being to get a load in both ends of the scoop.

In practice, however, we found that in pulling it back much of the sand was washed out by the water. To prevent this the foreman in charge of the work improved the design by having a cover fitted to the top of the scoop with a hinged cover on each end. These end covers are connected by a rod through the scoop so that when one cover is open the other is shut. The ropes by which the scoop

is pulled through the sewer are attached to these covers, so that whichever way the scoop is being pulled the rear cover is closed.

QUESTION.—I would like to ask how this operates in the different-sized sewers?

MR. BRANCH.—We have scoops for the different-sized sewers. We thought we might need them, and we had a set of different sizes made up—8-inch, 10-inch, 12-inch, 15-inch and 18-inch. I think we have just one place where roots have begun to grow into the sewers. It is in a street where there are willow trees on each side of the street, and we expected trouble there.

MR. FULLER.—I would like to ask, Mr. President, whether there is anything that keeps the scoop up from the bottom, or whether it draws along on the bottom?

MR. BRANCH.—It draws along on the bottom.

You were speaking about stoppages and cleaning devices. We found we had two or three stoppages right in the bend of the Y connections, and we devised something, which we have not had an opportunity to try as yet; we fit a spring, such as the plumbers use for bending lead pipe, to the end of our cleaning rod, with a chisel on that. We think that will go around the bend and clean off the obstruction. We have had about two or three of these stoppages right in the bend.

THE CHAIRMAN.—Where do you use this spring cleaning device?

MR. BRANCH.—In the house connections. All our connections are made in a direct line from the sewer.

THE CHAIRMAN—Are there any siphons in your city?

MR. BRANCH.—No, sir, we have no siphons.

MR. BARBOUR.—What is the length of the scoop?

MR. BRANCH.—The scoop is about three feet long.

MR. W. H. PATTERSON.*—We have some lines of 15-inch sewers that are laid at a grade of one foot in 1000. We also have one or two 18-inch sewers that are laid one foot in a thousand. I will say that our 18-inch mains laid at that grade are not costing us any trouble at all. We have one section of 8-inch pipe, about 500 feet in length, that is laid where the state bath house connects with our sewer. Some three years ago the bath house connected directly with the mains, and some three inches of sea sand had collected in this pipe, which I have been unable to clear out until this spring, but I think I shall be successful in doing it now. That pipe was laid at the same grade as the 15-inch pipe, and we have cross connections coming in from a 12-inch pipe, which causes practically a dam.

* Superintendent of Sewers, Revere, Mass.

That of course has made some trouble, and yet we have worked along with it. I have been obliged to flush it in the summer months as often as every two months, but I have never had any serious trouble with it. The outfall sewer runs to a receiving tank, which discharges only on the outgoing tide, and the quantity of sewage is so great that the tank has not sufficient capacity, and the sewage backs up into the sewers; consequently we are making a storage tank of our whole system. We have some 2000 or 3000 feet of that 18-inch pipe laid at that grade, and at every tide we find that we are backing up and filling up our system. Of course that has considerable to do with the matter of keeping it clean. But I think we will not have trouble with it. I am using a scoop that was made by Mr. Harold Vaughn, and apparently it is doing the work; I am just beginning to use it, and I am not thoroughly satisfied, but I hope we will be able to make it work satisfactorily.

We have some flat sections where small sewers are laid, as flat as one foot in 800, and that has not caused us any trouble.

The flushing of the system is entirely by fire hose. We work by sections. We get from 65 to 70 pounds pressure at the hydrant, and use 500 or 600 feet of hose. It of course reduces the pressure at the manhole quite a little, yet I think it is doing and has done good work.

Now, Mr. President, in relation to roots. We have had considerable experience with them this spring. We had some sections where there were roots growing. I had one section of 8-inch pipe that was laid a little better than 10 feet in 1000, and I have cut roots from that pipe this spring. It is wonderful to me how the sewage ever got through, but that section has been in operation all the time.

I first discovered there were roots there nearly three years ago, but I was unable to get the necessary tools to cut them out until this spring. We kept the system in operation, but it had gone about as long as I dared to trust it. Those roots are full of worms, dirt and all kinds of matter, and still the sewer was doing its work; it was not even backing up from one manhole to another. Of course I cannot understand how it was done, but it was done just the same.

I am now cleaning another section where we had a stoppage some two years ago from roots. I managed to cut the roots, and got it started, and it is working all right since, but we are taking out bunches of roots somewhat smaller than those found in the first section.

I agree, Mr. President, with the gentleman from Malden. I believe it is all in good construction. This pipe was laid some 12

years ago, and it was done by contract work; and the committee in charge of the work, so far as I have been able to learn, insisted that the engineers employ local men for inspection, and it would make almost anyone dizzy to look through the pipes. The pipes which have been laid within the last few years have not bothered us. As Mr. Wetherbee has said, when you get them as straight as a gun barrel, so you can see right through them, I don't think you will have any trouble with them. That is the way with those that we have laid in the last two or three years. When you get the joints so that the roots cannot get through, you do not have much trouble.

Mr. Fuller.—Were the roots solid?

Mr. Patterson.—They were in a solid bunch, and filled with sewer dirt. I have several bunches of roots that I cut when I first started out, and if I had known the discussion was coming up here I would have brought some up here to-night.

There is one peculiarity, Mr. President, that I would like to speak about. When I first discovered these roots running through the pipe I reached into the side of the pipe and gathered up a small bunch of roots in my hand and when I brought those roots out of the pipe, there were three spears of green grass growing on those roots. I called it to the attention of the men there and we wondered and always have wondered how they got there, but they were there just the same.

Mr. President, I don't know that I want to say much of anything more in relation to flushing, but there is one thing that perhaps I did not finish up.

When I found we were getting sea sand, we caused a change in the bath-house connections, and connected with a catch basin, which I think effectually stopped the sand coming into the sewer, but I have not got rid of the sand that I received previous to that time. I am in hopes to do it with the use of the scoop, but it is not very fast work. Of course it is continually working, pushing it in and pulling it out, and I think we get the scoop about two-thirds full easily. We get through, ordinarily, 200 feet of pipe, with four men, in a day.

A Member.—Mr. Chairman, I should like to inquire in the case of roots if it is fair to suppose the pipe was broken in a great many cases?

Mr. Patterson.—I don't think the pipe was broken at all; I think they all came through the joints. I undertook to look into one section, and, so far as I could see, I think in nearly every joint there were from one to half a dozen of the roots coming through.

Mr. A. A. Adams.*—It is an unexpected pleasure to be here. I can say that we have in Springfield a combined system of sewers made up of about 25 miles of masonry and 75 miles of pipe sewers. For flushing purposes we have direct connections with the water system at all terminal and some intermediate manholes. The flushing is done continuously, the entire system being flushed in from four to six weeks, which seems to be often enough. We have not had a great deal of trouble with gravel and sand in the sewers, and I know of but two instances of sewer stoppages on account of roots, one case being accounted for by lack of proper attention.

The Chairman.—What is your minimum grade?

Mr. Adams.—That is a matter I am not very familiar with as our engineer lays out the sewers. I think, however, that our minimum grade approximates one and six-tenths feet in one thousand feet.

Mr. Eddy.—Mr. Chairman, I want to say just a word about grades. You asked about 15-inch in sanitary work. I cannot tell you about that. But I find in this table we have in a combined system an 18-inch sewer laid at grade of .62 in a thousand feet, also a section .58 in a thousand feet, which comes pretty near one in two thousand, and that is where we have some trouble with deposit as we have to scrape that section out. Where we do not have trouble the minimum slope is 1.7 in a thousand. I have no doubt, from observation, that this sewer, laid at .58 in a thousand feet, would give no trouble in a separate system. There has been a question raised by Mr. Branch concerning the growth inside of the sewer. If I recollect correctly, the town of Westboro had a great deal of trouble with growths inside of the sewer. I don't remember the name of the fungus, but I think it was caused by a large amount of ground water getting into the sewer. The pipe was relaid, and my impression is that there was no more trouble after that. You will find a description of that on page 674 of the State Board of Health report for the year 1898.

Mr. E. C. Frost.†—Mr. President and gentlemen: Our system was designed and built in 1888, a separate system, containing about 15 miles at the present time, at an expense of about $225,000, including pumping station, force mains, filter beds and everything in connection therewith.

We flush our sewers with the hose and hydrant about four times a year.

There is one thing which we formerly did which we have

* Superintendent of Streets and Sewers, Springfield, Mass.

† Superintendent of Sewers, Framingham, Mass.

neglected for the last three or four years, which I propose to do this year, that is, near the dead ends to put in quite a liberal shovelful of potash. The gentleman on my right said that he had considerable trouble with small pipes from a greasy substance clinging to the sides and leaving a clean channel in the center. I think if he would try the potash he would clean the brick so the grease will not adhere to it so quickly. I know it works well in our place and it costs very little.

In flushing I use an open inch and a quarter nozzle. I have been able to clean out stones the size of a hen's egg with my inch and a quarter nozzle. We have a hydrant pressure of 94 pounds, and with a little calculation you can clean the sewers out pretty clean.

We have laid within the last three years, with the assistance of the Commonwealth, about $1\frac{1}{2}$ miles of 18-inch iron sewer pipe with lead joints. This sewer runs under the Sudbury aqueduct in an inverted siphon, which has been in operation about nine months and has given us very little trouble. This siphon is flushed by closing a gate at each side of a manhole situated at the upper end of said siphon and filling said manhole with water; then, by raising the gate, the sludge accumulation is removed by the water pressure. This may be repeated until the siphon is clean.

There has been considerable said about roots growing into sewers. I think the trouble all comes in construction. There is no question about that. I have gotten roots three or four feet long out of sewers. Maple roots will grow in through a brick wall; they will go through where some man who didn't know his business, and was not watched, has left a little bit of the jute sticking out through the joint. If sand gets between the pipe and the cement in construction, the roots will grow around between the sand and the pipe and get into the sewer.

There is very little satisfaction cleaning roots out, because they grow right up again. When you find roots in the sewer, the best way to do is to dig it up and lay it over.

In regard to our filter beds, we have about 21 acres under cultivation, and we are pumping about 900,000 gallons of sewage, and we have had no trouble taking care of it, except I came pretty near being frozen up this winter, with the large amount of snow we had. I think some of the Worcester people can sympathize with me in that respect. Where I have a bed that takes 900,000 gallons for three days, in ordinary times I could fill that bed in three hours with the same flow, so you see our beds came pretty near being tied up. I have thought sometimes that in inland towns in Maine (in a climate colder than ours) this system

of purification was practicable, but after passing through last winter, I have changed my mind.

Mr. Bowers.—I would like to say, Mr. President, that I have had considerable trouble with roots in sewers and I want to say that I agree with what the last man said. The time spent trying to cut off the roots is all wasted and I think when you find the roots you had better take up the sewer and relay it.

Mr. Frost.—Just one more word to tell you what roots can do; the water for our boilers comes from a pond through an 18-inch Akron pipe, with Portland cement joints. There is one place near the pipe where there were a few willow shrubs growing. A year ago this summer we could get no water for the boilers through this pipe, and I found the roots from these willow trees had grown into the 18-inch pipe. One was 20 feet long, one 24 feet long and the other 30 feet long, and they filled the pipe so full that a muskrat could not get through. One had tried it and his carcass was found among the roots. I had to break the pipe at the point where the root grew through, in order to remove what had grown inside the pipe.

FABLE AND FACT AS FACTORS OF PROGRESS.

ADDRESS BY J. L. VAN ORNUM, PRESIDENT OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club, December 16, 1903.*]

AURORA, radiant goddess of the morning, was represented by the civilization of the ancient world as standing in a chariot drawn by winged steeds, one hand grasping the reins and the other holding a torch, while a brilliant star sparkled in her forhead; thus she dissipated the gray twilight of the morning by her splendor, awakening the dark sphere to a glorious life as her swift steeds flew across the world. What imagery could better typify the import and achievements of modern transportation?

Consider what our civilization would be without the steamship and the locomotive. Although they have been in operation less than a century, the civilized world has been completely transformed by their agency and by the later perfection of the electric car. The motor-car and carriage are even now exerting their influence upon our civilization, tending powerfully to remove the great contrasts between urban and rural life to the advantage of both; while the final conquest of nature by the subjugation of the air bids fair to complete this Eoan simile.

Contrast the facility of travel now with its difficulties when not served by these agencies; a journey to the Pacific meant months of hardship where now only an equal number of days is needed; or compare the fatiguing journey of Washington to his inauguration, consuming days where an equal number of hours now covers the distance in comfort. Ocean travel has been transformed since the "Savannah" in her passage from Georgia to Liverpool, in the year 1819, first used steam.

The history of the great Santa Fe Trail illustrates forcibly many such contrasts. In the early part of the nineteenth century this great overland route of nearly a thousand miles consumed a season for the journey from the Missouri River to Sante Fe and return. It was not until 1829 that the introduction of wagons was effected, rendering transportation possible though the difficulties and dangers were still great. One party, having lost its animals in a stampede and forced by hostile Indians to abandon its supplies and to walk to the settlements, thus describes its experiences:

* Manuscript received September 20, 1904.—Secretary, Ass'n of Eng. Socs.

"After eight days' travel, despite our most rigid economy, an inventory showed that there was less than one hundred pounds of flour left. Day after day the hunters repeated the same old story. 'No game'! For two weeks the allowance of flour to each individual was but a spoonful stirred in water and taken three times a day. . . . . Now, in addition to the pangs of hunger, a scarcity of water confronted us, and one day we were compelled to resort to a buffalo wallow and suck the moist clay where the huge animals had been stamping in the mud. . . . . Having journeyed (for weeks) until we supposed we were within a few miles of the settlements some of the number, scarcely able to travel, thought the best course to pursue would be to divide the company, one portion to pass on, the weaker ones to proceed by easier stages; and when the advance arrived at the settlements they were to send back relief to those plodding on wearily behind them. Soon a few who were stronger than the others reached Independence, Missouri, and immediately sent a party with horses to bring in their comrades; so at last all got safely to their homes."

During the next twenty years the time of a trip was gradually reduced to somewhat less than three months, and the cost of hauling freight was reduced to $200 per ton; while the tariff now on merchandise by train is about one-sixth that rate. In the score of years preceding the approach of the Sante Fe Railroad, Concord coaches were in use, charging $250 for each passenger, and gradually reducing the time to two weeks. The trip was continuous, night and day, "With no chance to stretch your limbs, save for a few minutes at stations while you ate and changed animals." Now this same route is traversed in comfort in one and one-half days, and at a cost of less than one-eighth of the charge just given.

The saving in time and comfort of travel is not the only significant result. The safe, speedy and distant transportation of commodities is of equal importance. Grains from the higher latitudes, meats from the piedmont ranges, fish from the seas and fruits from the tropics are collected with equal facility in our centers of population. We have only to compare the conditions of our own republic with those of less progressive countries to realize the full import of modern transportation. Even now famine decimates the population of various provinces of India when there is a local failure in agricultural products; starvation would be equally our inheritance if we were without modern transportation facilities.

Of course other agencies have also profoundly affected mankind in its progress; but I know of no single influence which can be so significantly pointed out as typifying the beneficent achievement

of the present day as that of transportation, which is the engineering interest which unites the most completely all our various branches—civil, mechanical, electrical, mining, metallurgical and marine. Thus did Aurora in her chariot well typify transportation; the winged steeds signifying its speed, the guiding reins indicating its perfect control through the power of steam and electricity, and the lighted torch emblematical of the enlightenment of nations that has resulted.

Homer tells us that Neptune rose from the depths of the ocean and traversed the entire horizon in three steps. This dream of marine mythology was surpassed by the achievement of the ocean cable laid by Cyrus Field less than fifty years ago; and the extravagant fancy of the king of dramatists uttered three centuries ago "I'll put a girdle round about the earth in forty minutes" has been more than realized within the year, when a message was sent around the world in less than one-fourth that time.

Artemis, the young and swift huntress, with her bow and quiver on her shoulders, pursuing her course as rapid as the winds, may typify the modern telegraph which Morse made practicable sixty years ago. And Mercury, the swift messenger of the immortals, "The fleet, inventive idea sent from heaven to earth," is emblematical of the telephone which has been a real necessity in our busy life for a score of years; even the remarkable fidelity in reproducing the tones and modulations of an individual voice at great distances is suggested by the attribute of inventive cunning given to Mercury by the ancients.

Among mythological deities the winged Pegasus was supposed to especially preside over fountains; and where his hoof struck the earth springs would gush forth. The god-like Perseus, son of the all-powerful Jupiter and the arid earth, when suffering of thirst secures water by plucking a mushroom from the earth and so causing a spring to flow from the place it occupied. The great, and sometimes surpassing, importance of water as a factor in the productivity of some of the Mediterranean countries is indicated by the fact that the supreme Jove himself is represented as striking the earth in a particularly arid region and thus causing the essential fluid to flow in abundance.

The modern miracle brings water from the earth by no divine dispensation, but so constantly and with such compelling power that waste and arid places are transformed to choicest lands. One section of our country (which, thirty years ago, was a sandy waste with only occasional flocks and herds securing but a meager return to the few inhabitants) has been transformed by this agency alone into a region whose productivity is ten times the average for agricultural

lands; whose income per inhabitant is a hundred dollars per year; and whose transformation is more wonderful than that told in the legendary myths themselves because it is so general. This instance is but one of many where the vivifying flow of the developed streams has awakened these arid, forgotten lands from their doom of solitude and silence to their rightful sphere of richest fruitfulness. Even yet these pioneer communities are but the outposts of the conquering power which has but just begun the great, decisive campaign against nature in her most forbidding mood, whose strategy rests in the quiet but compelling control of the irrigation engineer.

You will remember that Prometheus, in endeavoring to kindle his torch at the chariot of Phœbus, incurred the opposition and wrath of Jupiter; but he finally succeeded in evading the angry deity by concealing the ethereal fire in the stem of a reed. And so approaching his creations on the earth with the divine flame they responded to the influence by beneficent activities. What imagery could more aptly typify the silent but constraining power of electricity in our day than does this legend of that inventive genius whom mythology credits with teaching men the useful arts?

The mining engineer is, perhaps, foreshadowed in Theseus, who dared to descend to the depths of Orcus to bring back to the light Proserpina, the goddess in whose hands lies the fate of men (as it so often seems to lie, especially with the precious metals). Whitney's cotton gin, the Hoe printing press and other mechanical wonders are certainly not less marvelous than were the stones which Deucalion and Pyrrha threw behind them, so changing them into human beings. The beautiful but suffering Niobe, mercifully turned into stone by the pitying gods, may be symbolical of cement. The Aloeidae, who strove to place Mount Ossa upon Olympos and Pelion upon Ossa, easily suggest the designer of high steel buildings of to-day. Phaëthon, rashly aspiring to drive the chariot of the sun for a day, was for his presumption struck by a thunderbolt and hurled into the river Eridanos; to-day our river of the Falls yields electric energy surpassing a thousand thunderbolts in power. As the prototype of all the varied interests of the engineer, what better character exists in all mythology than the stern and daring Minerva, goddess of the liberal arts, civilizer and benefactress of mankind, whose very symbols* were considered the badge of strength and wisdom.

Such were some of the fancies and conceptions of the human

* The Gorgon's head on Athena's breastplate.

mind in the early dawn of civilization, when desires and needs were perhaps as great as now, but when attainment cheered only those divinities whose achievements were the Utopian dreams of mortals. And such again are some of the facts of the modern world, actualities whose reality are so interwoven with our every-day life that they seem no longer wonderful. There was the prototype, here is the product; there the dream and prophecy, here a fulfillment even now surpassing the imagination of the ancients, while the future abounds in greater possibilities and promise.

The poetic minds of the ancient civilization conceived such fantasies of surpassing achievements, weaving them into legendary tales in which the characters possessed powers and attributes most extravagant. In this atmosphere of legendary prowess successive generations of the cultured classes dreamed their heroic dreams and achieved somewhat, while the masses of men toiled in ignorance and slavery, making "bricks without straw," irrigating fields with the foot, gleaning grain with the sickle, mining by the excessively tedious and dangerous "fire-setting" system; navigating, but as galley-slaves; warring, but as conscripts; engaging in overland commerce, but by wagon-train or caravan; constructing aqueducts to supply the masters, not for the general salubrity; erecting monuments, temples and other works, for the delectation of the few. The achievements of the ancient world were such that the mass of men could have in them no personal interest or part. While the few aspired and flourished, exhibiting in themselves the ultimate in their civilization, such favored ones inevitably were doomed in the might of the virile upheaval of the barbarian hordes. When that classic culture fell, none could perpetuate its splendor; for the refinement of the ancient world had been segregated and secluded, and its vigor had become so attenuated even among its devotees, that its power to vitalize mankind was gone.

Many centuries passed. A new principle was struggling for expression during the lethargy of the dark ages. Among all ranks of men there were those who variously tried to impress the supreme import of the brotherhood of man. Some labored feebly, others vociferously, and others again strove by force of arms to impress the truths of human interdependence. But their resources were so circumscribed, the horizon of endeavor and influence was so narrow that progress was spasmodic and most uncertain until abstract principles were vivified and given opportunity by the unfolding energies of the modern world.

What real significance had "humanity" when thousands starved for want of that which was plentiful not far away? What virtue

had "fraternity" in the crowded, reeking cities until the sanitarian banished the plague and insured their salubrity? To the humanist "brotherhood" became significant when the printing press, railway, steamship, telegraph and telephone brought all the world within his interest; and "altruism" could claim the world for its dominion when the engineer had brought the world within its reach.

Classic story charms the hearer, offering its Utopian dreams; humanistic disquisition inspires the thinker, contemplating human interests; and science, pure and applied, absorbs the energies of him who pursues its unfailing principles. The first idealizes; the second moralizes; the third executes; and who would say that the last is of less import than the rest?

Unquestionably the classicist by no means confines his interests to idealization, nor the humanist to dissertation, nor the engineer to accomplishment; it is merely attempted here to indicate the characteristic spirit animating each. Occasionally very intolerant views have been expressed by men who could see little of culture, mentality, wisdom or worth in those whose life and interests were diverse from their own. For example, recall Lowell's definition of a university as "A place where nothing useful is taught." Even recently one of our college presidents said "Technical schools have their place, but they have no part in a university." The former statement may be due to that ancient attitude of the feudal mind whose capacity was of one dimension only—that of length; and the latter partakes of the pseudo-practical, thinking to attain to volume by assuming the added attribute of breadth. The third dimension—depth—has been brought by him who directs the forces and resources of nature to the use and convenience of man; but its coming was not helped by such misconceptions. Such intolerant views, rapidly getting rarer, are survivals of the aristocratic spirit in education, which has practically disappeared before the democratic tolerance of the present, infusing a new vitality into education and transforming it from the feudal type to one of broad beneficence. Traditions had and have their part, idealizing toward the intellectual and spiritual; disquisition finds its most abundant reward in the culture of society and the exaltation of citizenship; and "The priest of material progress" has intensified living and enlarged the scope of life until it has no horizon but the limits of the universe.

Action, thought and life itself have become intense, until a decade of the present accomplishes more than a thousand years of the ancient world. Activity is an unfailing index of life; and if the index points high should not we read the record as indicating a more profound and abounding life? The engineer is often charged

with much responsibility in connection with the strenuous vitality of the present; and truly so. But when his spirit of energy is charged with increasing the burdens of the world, I must protest. These intensities of life are functions that are involved in life itself,—the duty placed by Providence upon all who live to swell the sum of life's veritable accomplishment. The engineer, then, through the avenues of his endeavor, has assumed life's duties with the constant aim of enabling the world to fulfill its destiny with the least expenditure of human energies. The purpose of his activities is not to add increasing burdens to the tense life of modern civilization; but, accepting willingly life's law of progress, his purpose is to conserve, and so to promote the powers of mankind.

The engineering profession is never charged with lack of depth. Rather does communion with nature's laws and resources give cause to fear that such profound pursuits may tend in him to overshadow that breadth of human interest and that limitless mental vision which all unite to mark the man of equipoise. The three types of mentality which I have indicated are in fact co-ordinate attributes of him who would fulfill his destiny the most completely. And so, consecrating to the service of mankind the apprehension of life's verities, the power to execute and the perception of the ideal, there shall be realized the fulfillment of the prophetic Minervan legend; the union of power and wisdom beneath the ægis of the world's accumulative attainment.

THE DISPOSAL OF MUNICIPAL REFUSE.

By F. K. Rhines, Member Toledo Society of Engineers.

[Read before the Society, July 16, 1904.*]

When the human race became sufficiently advanced to abandon its former nomadic existence, congregate in considerable numbers and erect permanent habitations, there was of necessity given it the problem of disposing of the rejected by-products of existence. The need for removing excreta and other deleterious liquid and semi-solid matter must have demanded early attention, although the development of the sewer system to a point of real efficacy has been the work of the modern engineer, and the final disposal of sewage is a subject to which much study can still be devoted with profit. But the removal and destruction of what may be termed "surface wastes" is distinctly a feat of the nineteenth and twentieth centuries. The scourges of cholera and "black death," which ravaged England and all Europe, were, even at the time, recognized, somewhat dimly perhaps, as related to unsanitary conditions; and great centers of population at a much earlier period took sporadic and ineffectual measures to get rid of the most offensive elements. We do, indeed, find mention of such in the time of Moses, and the enforcement of certain sanitary regulations was common to others of the more advanced races, but it is hardly likely that the ancients allowed themselves to be seriously troubled by what must have seemed an insignificant matter in comparison with the all-important questions of arms and conquest; and with the notable exception of the incineration of human bodies practiced by the Greeks, and to some extent by the Romans, such efforts were confined to dumping or tipping upon land or water, which, in the light of modern experience and investigation, cannot be considered as final disposal.

And yet to within the present decade, the greatest city of our country has depended upon this makeshift. It is scarcely three years since New York stopped barging her refuse out to sea, and abandoned, forever, let us hope, a practice which was a constant source of dissatisfaction to all concerned. And who is not concerned in such a matter as this? It is a question which touches the well-being of every citizen, and, as such, certainly merits the most serious attention.

Despite the fact that some very eminent hygienists contend that garbage is only detrimental to health in so far as the noxious odors

* Manuscript received October 12, 1904.—Secretary, Ass'n of Eng. Socs.

exuded tend to deplete the human system, it is pretty well established that putrefying animal and vegetable substances are not only a frequent vehicle of disease, but that decaying organic matter affords a favorable breeding ground for zymotic disease germs.

An example of the most flagrant violations of sanitary precautions in this regard, and of the inevitable penalty, is to be found in temporary army camps. It is said that in the Civil War more soldiers died of dysentery and camp fever than were lost in battle. Those who are familiar with the conditions that prevailed at Chickamauga Park, during our recent war with Spain, will not for a moment question the cause of the shocking amount of illness among our troops—and this in one of the most healthful mountain regions of the entire South.

Was there ever an army thrown into the field, where proper sanitary measures could not be, or were not, taken, that did not have this subtle enemy to fight?

It has been said that epidemics are Nature's greatest health officers, and if this be so, interest ought to be widely stimulated by the recent experience of Butler, Ithaca and others. Just as Nature is unrelenting in her punishment of unsanitary modes of life, she is gracious in the reward of every effort toward better conditions. The cleaning up of Havana by the American military cut the previous normal death rate squarely in two, and it is hoped that as much can be done at Panama.

To cite just one instance a little nearer home: The city of Memphis, Tenn., has so successfully controlled her yellow fever by the adoption of a sanitary method of disposal of her municipal waste that the city has not been quarantined since the construction of her plants. From 1898 to 1904 her death rate has dropped from 22 to 15 per thousand.

Primarily this question is a sanitary one, but the tendency of engineering practice is to ally itself more and more closely to the great sanitary problems of the day. Sewer design and sewage disposal are conceded to be wholly the engineer's problem, and although garbage disposal in most of our American cities is under the direct charge of the Health Officer or the Board of Health, each day sees the question more frequently referred to the sanitary engineer for advice and recommendation, which the writer believes to be encouraging as conducive to an earlier and more satisfactory solution. But it must not be forgotten at any point that the prime object is always perfect sanitation, and that the process which sacrifices this, however ingenious and otherwise efficient, cannot be accepted as the ultimate solution of the problem.

The average composition of the refuse of New York, London, Boston and Berlin, as given by Morse, is as follows:

	New York.	London.	Boston.	Berlin.
Ashes	80.47 per cent.	81.55 per cent.	75.88 per cent.	52.97 per cent.
Garbage	12.20 "	14.20 "	20.19 "	32.54 "
Refuse	7.33 "	4.25 "	3.93 "	14.49 "

in which a wide variation is apparent.

Mr. Parsons gives the total refuse production per capita per week day as follows:

New York	3.9 per cent.
London	1.6 "
Berlin	.9 "

The amount given for New York, he estimates to be composed of: Garbage, .4 pounds; ashes, 2.5 pounds; rubbish, .3 pounds; street sweepings, .7 pounds; total, 3.9 pounds.

For purposes of more intelligent consideration, the general refuse production may be conveniently classified as follows:

I. Ashes (factory and domestic).
II. Street sweepings.
III. Rubbish.
IV. Garbage.

Then there are various special classes to be dealt with in different localities.

Prominent among these are:

V. Dead animals.
VI. Night-soil, or human excreta.
VII. Hospital refuse.
VIII. Trade refuse.

Disconsidering in this paper the question of primary collections, which, with all its importance and magnitude, may be easily mastered by careful study, it will be attempted to show the difficulties in the way of disposing of each class of refuse and a few of the reasons some methods of disposal succeed, while others fail to accomplish the ultimate elimination of the rejected matter so far as that is physically possible.

I. *Ashes.*—Being practically free from organic matter, ashes, if unmixed with other refuse, are in no way offensive, except for the dust given off when handled, and the question of what disposition to make of this class becomes merely one of expediency and economy. The common method uses them in redeeming waste lands. The points which make this economical, or the reverse, are,

the (a) distance necessary to haul the material, and (b) the value of the land thus reclaimed.

The question of expediency can rarely be given serious consideration, since, under existing circumstances, it is generally impossible to do anything but dump them, though a small portion, consisting of sharp steam cinder, is frequently worked into concrete, and some ashes find their way into mortar and road pavements. A number of our seacoast towns make excellent use of their ashes in reclaiming alluvial lands, which sometimes develop immense values. The extension of Riker's Island by the New York Street Cleaning Department, where some 70 acres of fill-land have been made, is valued at $10,000 per acre, but needless to say this is an exceptional return.

II. *Street Sweepings.*—In many instances, where these can be kept free from dry rubbish, these are profitably utilized as filler, but are not well adapted in all cases on account of their fibrous nature, due largely to the manure which they necessarily contain. Organic matter in street sweepings takes in the wide variance from 4 per cent. to 60 per cent., according to the nature of the pavement and other changing conditions. In addition to this volatile matter, tuberculosis germs are common, and the bacilli of diphtheria and typhoid are not infrequently found.

In short (though its manurial value in special cases has been demonstrated), the proper method of disposal for this class of refuse is not generally recognized, but its composition as well as the best practice seem to point to treatment by fire.

III. *Dry Rubbish* is admitted to be of value. In New York 35 per cent. is readily marketed, bringing to the city over $100,000 per annum. Say, 5 per cent. is incombustible and worthless. There is yet a balance of 60 per cent. of dry, combustible refuse, with a positive, albeit indefinite, calorific value. The solution here is obvious. This class of refuse should be made, in one way or another, to assist in the destruction of the offensive and less combustible matter, and the writer believes that with proper apparatus, even the percentage of marketable material can be better utilized for producing heat, and at the same time doing away with the unsanitary sorting process necessary to separate what is sold, resulting in a saving of both health and steam power. In London, let it be remarked, this degrading work of "picking" the refuse is performed largely by women.

IV. *Garbage* presents the chief difficulties to be met in the consideration of this entire subject. When it is remembered that this includes all manner of refuse from the kitchen, market, hotel,

commission house, fish stall and slaughter house,—in fact every sort of animal and vegetable matter, with, commonly, a considerable proportion of such inert matter as tin cans and broken crockery, and, frequently, small dead animals, it is seen at a glance how many factors lead to the complication of the disposal problem in this application. The system which will successfully dispose of one constituent must often utterly reject the others, while the process to have our ultimate and unqualified commendation, must care for every portion of this heterogeneous production with equal efficacy and without undue expense.

Solid garbage is about 20 per cent. putrescible organic matter, frequently highly infected, and its prompt collection and thorough destruction are imperatively demanded.

Among the methods for disposal now in common vogue may be mentioned:

1. *Dumping*, which is effected in three general ways:

   A. Upon Land, { (a) as filler. (b) as fertilizer.

   B. In Streams.

   C. At Sea.

2. *Feeding to Swine.*

3. *Utilizing by Reduction.*

4. *Cremation.*

1. *Dumping.*—There is little argument that can be advanced in favor of this method, unless it be its antiquity. It is of interest here to note that in the English city of Portsmouth, which is still disposing of its refuse at a dump, or "tip," as it is called in that country, the Mayor was arrested in the year of 1694, and fined 6s. 8d. for tipping refuse in a public street; but this should by no means be taken as typical of English progress in this direction, as our friends across the water have given us much food for thought, as will later be shown.

(A) *Dumping Upon Land.*—Naturally, the first object in dumping garbage is to dispose of it. Apart from this must be considered the resulting advantages and objections of the method. (a) As a filler for lands upon which buildings are to be subsequently erected, garbage has shown itself to be utterly unfit. In experiments made at Brussels, garbage having lain on the dump for over nine years was found to contain more than 30 per cent. of organic matter, and a similar investigation at Boston developed the fact that after lying for ten years decomposition was still in progress. Unsanitary building sites became a sufficiently serious cause of danger

in London to occasion legislation prohibiting the erection of any building upon ground which had previously been used as a tip.

The most serious hygienic objection to this unsanitary practice is the danger of infection of the scavengers and "pickers" who make a practice of going over the material as it lies on the dump, pulling it apart and forking it over, searching for whatever may be of value. These persons are nearly always personally unclean, in feeble health and, living in crowded districts amid unsanitary surroundings, are the very class most likely to contract disease and carry it to others. If for the time the dump nuisance must in some cases be tolerated, this offensive and dangerous practice should at least be abated.

(b) As a fertilizer, more can favorably be said. For enriching certain kinds of sterile and impoverished sandy soils, garbage has been used with good effect, notably in some parts of Europe, where the fertility has been largely increased; but in this country at least, the cans, crockery and other rubbish commonly found in the garbage are very troublesome, and it is also difficult to find lands upon which to utilize the production of large cities.

(B) *Dumping in Streams.*—The decomposition of organic matter in water is very slow, and garbage dumped into rivers and small streams is usually carried down to pollute the water supply of other cities or towns, or to be cast up on the banks to become a prolific source of nuisance. It will be seen that this is not final disposal at all, but simply a shifting of responsibility in which no community has the moral right to indulge. The system is altogether false in principle, and cannot be too earnestly denounced.

(C) *Dumping at Sea* is subject to many of the same criticisms applied to the practice in interior regions. There is, it is true, the possibility of taking the material so far from shore that a comparatively small part of it will ever find its way back; but at New York, even when the garbage scows were taken as far as 50 miles out to sea, enough of the refuse was floated back to cause serious annoyance at the Long Island beach resorts, and the practice has finally been discontinued. A similar experience was had at Marseilles, and many others could be cited.

The city of Havana, after having been started in the right direction by the establishment of a crematory plant, is still sending a couple of hundred tons to sea daily, but it is not likely that this will be long continued.

2. *Feeding to Swine.*—It would appear at first glance that this is hardly an engineering problem, but the engineer is nothing if not an economist, and as this means of disposal still finds favor in

many of our American towns which cannot be called unprogressive, it is worth our looking into.

If it is not necessary to haul the garbage an unreasonable distance and local circumstances make it possible to secure an approximately uniform production of a proper quality of pure garbage, the financial economy cannot be questioned; but the expense of delivery is radically increased by the necessity of more frequent collection, and here again an objectionable feature is found in the foreign matter contained. Keepers of large hotels, who are frequently able to sell their garbage for this purpose, are justified in the special effort required to keep this material separate from the table offal, but it has been found extremely difficult, indeed well nigh impossible, to enforce such a separation generally throughout a city, and this objection becomes, therefore, so insurmountable as to preclude the possibility of adapting this method generally to the entire garbage production. The disease germs which are carried by the garbage become, moreover, a frequent source of menace.

3. *Reduction.*—An average analysis of city garbage is as follows:

Water	70 per cent.
Animal and vegetable matter	20 "
Rubbish, cans, rags, etc.	7 "
Grease	3 "

The reduction process consists, briefly, in extracting the grease from the balance of the material. As this is the smallest percentage, as shown above, the process is necessarily a laborious one.

In the first place, if not for the successful, at least, for the economical, operation of the process, the exclusion of all rubbish is absolutely necessary. The "pure swill" is cooked, usually by steam, in huge "digesters," which are steel tanks holding some 6 tons each. By the introduction of naphtha and benzine the grease is separated and removed, and later the residue is subjected to immense pressure to free it from water. What then remains, commonly known as "tankage," is of value as fertilizer base, but its marketing is such an uncertain element that it frequently becomes necessary to throw it away or burn it in order to dispose of it at all. Fair prices for the by-products are $60 per ton for the grease, and $6 per ton for the tankage, which superficially look rather inviting. But, as a matter of fact, no reduction process has yet demonstrated its ability to pay its own expenses, much less a dividend on the investment. The reduction system is now in use in some 25 American cities, and has been tried and abandoned in nearly as many more.

A few of the reasons why it has failed so frequently, and why its use is so slowly adopted are found in (a) the heavy cost of installation, (b) the cost of operation, (c) complexity of machinery required, (d) fluctuation of prices obtainable for the by-products, (e) difficulty of operating the plant during epidemics, (f) impossibility of locating the works in or near centers of population, on account of offensive operation, and consequent heavy expenses for transporting garbage; and (g) further, in the commendable hesitancy of municipal authorities to embark their civic charges upon such speculative enterprises.

It should be remembered that, even when comparatively successful, this process disposes of less than 15 per cent. of the total municipal waste production. At Barren Island, the New York City plant, where are located probably the most extensive reduction works in commission, the amount cared for is given by one authority as 8.5 per cent., by another 12.2 per cent., of the total waste production, and often the fact must be faced that even this amount is not finally disposed of, for after the grease has been extracted the crematory may have to be resorted to for the disposal of the residuum.

Reduction is, after all, closely allied to "picking" and "sorting," although done in a mechanical way, and has been aptly characterized as "an attempt to save something which is not worth saving."

4. *Cremation* is now practiced in about one hundred American towns, and it is being considered by at least one hundred more. It offers, to the hygienist at least, an ideal solution of the problem, and the limits of its possible application have as yet by no means been determined. While in England the crematory generally cares for the ashes, rubbish and garbage, it is common practice in America to cremate only the two latter classes, hence, we have immediately a radical difference in the problem as presented to the two countries. It cannot be denied that England has given this question more earnest study and applied a greater amount of engineering skill to its solution than is the case with us. This is natural, as in the first place, the need is greater, population is more dense, and when the garbage is not promptly removed, the health of the public is threatened to greater degree.

Crematories, or "destructors," as the Englishman calls them, were introduced abroad more than 25 years ago, while the first domestic experiment made by a municipality was in 1887; consequently, the English apparatus has gone through a longer period of development and improvement. Yet there is no desire to belittle the attainments of the English sanitary engineers, whose labors have

been crowned with such encouraging success. Nevertheless, a fair comparison of the inherent differences in the two problems should receive due consideration. The first has been hinted at above. Ashes, rubbish, garbage and sometimes even street sweepings are gathered up together and are in no way separated during their treatment at the "destructor." In America it has been accepted without argument, until it is almost considered axiomatic, that garbage must be kept and collected absolutely apart from every other class of refuse, except dry combustible waste, and, of course, in the reduction process even this must be eliminated. There is, moreover, a very prevalent sentiment against the draining of garbage, although it is hard to recognize any good reason why the liquid from garbage would be any more offensive or dangerous if put into a sewer than the matter already there. But the fact remains that the successful American furnaces have to receive and evaporate the full amount of water contained in garbage as it is collected from the houses. The average amount of moisture in garbage proper is 70 per cent., while that in the entire waste production of a city rarely exceeds 25 per cent. It is not strange, therefore, that the bare cost of destruction per ton is largely in favor of the English plant.

Further, it is obvious that the most economical work can be done where the largest amount of garbage is to be destroyed, and the largest, most modern and best equipped plant can be erected. Our American custom of placing such public utilities in the hands, and too often at the mercy, of a private contractor, has had, to a lamentable extent, the result of throttling sanitary progress in this direction. With the exception of recent noteworthy experiments made by the Street Cleaning Department of New York, some similar work at Boston, and the unfortunate experience of Milwaukee, with crude crematory furnaces, none of our large cities have erected municipal plants. The individual who has a short, or even a long, term contract, being in the business for what there is in it, will make no improvements in the process which do not directly increase his profits, and will not erect a plant of the permanence desirable in such works. There can be no question that our political system is at fault here. It would be as reasonable to let out the maintenance of a sewer system and operation of a sewage disposal plant to a private contractor. The result has been a forcing upon the smaller and less opulent towns and cities the brunt of the expense for most of the municipal experimenting and investigation that has been carried on with consequently, and quite naturally, a slower progress toward the goal desired.

The English destructor furnaces are built on the cellular plan;

the refuse being received and thrown first upon a drying hearth is afterwards raked or shoveled on to the grate proper, where it is burned. The residuum is clinker with a slight intermixture of fine ash. The steam boiler, generally of the water-tube type, is an integral part of nearly every modern English destructor plant, the power in most cases being used for lighting the plant, working conveyors and other machinery, and in at least one instance the condensation water has been made to supply heat for a public library and bath house.

A type of the most successful American furnace is an elongated shell of steel lined with fire brick, provided with a horizontal fire-brick grate, upon which garbage is directly dumped as received at the plant. Fires at one end throw flames above and below this grate the full length of the destruction chamber, and the escape of obnoxious vapors passing off from the garbage during the early stages of cremation is prevented by the "stench cremator," located at the base of the stack, through which all gases of combustion must pass, and where by the high temperature they are rendered innocuous. Small pieces of burning rubbish and impalpable particles carried off by the draft impinge on fire tile which are kept at a white heat and falling back are destroyed in the fire of the stench consumer. Owing to the method of operating American crematories, and the fact that the combustion is not continuous during the full 24-hour day, there is considerable liability of producing offensive fumes when fresh garbage is thrown into the heated furnace at the beginning of the day's work. It is at this time that the stench cremator justifies its existence, which has been loudly criticised by advocates of the English system. Most American furnaces work under natural draft, but when the first stage of combustion has been passed and the garbage is well dried out and burning freely, the temperature is sufficiently high to obviate further need of operating the stench cremator.

It is usual, abroad, to supply destructor plants with artificial draft. While Sturtevant fans are widely used, the steam blast seems to be in general favor. It would appear, however, from the high chimneys with which most of the plants are equipped that the English engineer has not yet had sufficient experience with artificial draft to be sure of his results; or else that the destructor dust (which contains about 15 per cent. of organic matter) and for the interception of which elaborate precautions have been taken, is still a frequent source of nuisance.

This is, indeed, the bugbear of the English plant, just as the production of gaseous fumes is of the American. One of the most

ingenious of the dust interceptors consists of an annular chamber, through which the smoke is forced with a whirling motion, depositing the dust by centrifugal force in pockets in the walls.

The English destructor has been so closely correllated with the power plant that in some cases its primary object has become secondary or incidental. As far as the sanitary operation is lost sight of and the question of profit predominates, and precautions which tend merely to prevent nuisance and which bring no income are overlooked or neglected, the operation of the plant becomes to that extent a nuisance. Instances of this kind have given the cremator of refuse abroad the same sort of backset which has been sustained at home through the frequent failures of crematories designed by ingenious mechanics without engineering skill or experience, and based upon false principles. It will, perhaps, be a tribute to our Yankee ingenuity, though it will give the engineer cause for thoughtful consideration, to mention that more than 150 crematory patents have been taken out by American inventors. Scarcely a half dozen of these systems are in successful operation to-day.

It may not be out of place just here to give a brief *résumé* of what has been accomplished on both sides of the water.

In some of our home cities operating crematories where fuel and labor are cheap the garbage has been continuously destroyed at 17 cents per ton. In others, the cost has run as high as 40 cents, 45 cents and even 50 cents; but 35 cents per ton may be taken as a fair average. The cost of destruction of foreign waste, averaged from the results obtained by six of the representative English designs of the most improved type, is 22 cents per ton. The average value of the steam produced, per ton of refuse cremated, at the same six plants, is 13 cents, leaving the net cost of destruction 9 cents per ton, as opposed to 35 cents in America. But consider this: the average production per capita per day is 3 pounds of waste, of which .5 pounds is garbage. This would be in a city of, say, 200,000 people, 300 tons of municipal waste, 50 tons being garbage. Now, disconsidering the cost of collection and hauling, which would be about the same in either case, the English plant has 300 tons of mixed refuse to dispose of daily at a cost of 9 cents per ton; the American plant 50 tons of garbage at 35 cents per ton, amounting respectively to $27 and $17.50 per day, a balance of $9.50 in favor of the American method. Furthermore, consider the disposal of the residuum, which at the crematory will average 5 per cent. (or 2½ tons), by weight, of the material received, and 30 per cent. (or 90 tons) at the destructor. In either system it is *possible* to dispose of

this in isolated cases at a profit to partially offset the cost of destruction, but this is too uncertain a feature to be reckoned on.

A further debit to the English operation account is found in the fact that from 15 per cent. to 40 per cent. of the steam produced is consumed by the forced draft apparatus necessary in the operation of this style of plant. The cost of the initial installation has been left out of the question entirely, while as a matter of fact it would amount in the case of the destructor to 100 per cent. more than the cost of the crematory.

There is probably no other branch of engineering in which theoretically like conditions produce such widely differing results. Many contingencies are responsible for this, but one of the chief causes is the class of labor it is necessary to employ, which is especially troublesome in steam-raising plants, on account of the machinery to be operated and cared for.

One of the most interesting phases of this entire question is that of steam production, which hinges directly upon the calorific value of the refuse. This, in turn, depends upon the character of the refuse, the season, state of weather and many other circumstances. It is also largely governed by the kind of fuel used by the householders, and its market price; for where fuel is expensive, it is naturally more carefully used than where it is cheap, and the refuse has a correspondingly lower percentage of unburned material.

It is estimated that the refuse of English towns within, say, 60 miles of the coal fields, has an evaporative value equal to 20 per cent. of its weight of coal. Of course, there is a wide variation not only in the different localities, but at different times in the same places. Ordinarily, 1 pound of refuse burned under forced draft will evaporate from .5 pounds to 2.25 pounds of water (an average equivalent of about 80 horse power per ton of refuse per hour).

Test runs frequently show an evaporation of 1.5 pounds to 2.5 pounds per pound of refuse, but taken on a continuous run throughout the year, an average of pound for pound is about as good as can be expected, and rather better than is obtained in most instances. A sufficient number of tests and analyses of American refuse have not yet been made to determine positively what its calorific value may be. Domestic ashes in New York City contain from 20 per cent. to 40 per cent. of unburned coal, while those from factory plants carry practically none.

The production of steam power in the cremation of organic garbage alone has not yet been developed to any marked extent. More or less preliminary experimenting has been done along this

line, and some tolerably satisfactory results obtained, but they are not sufficiently general or typical to serve as a basis for predictions on what can be done at any particular point with different classes of refuse.

An interesting study is afforded by some of our local towns which burn gas and oil exclusively as fuel. It may be reasonably inferred that the refuse from such places would be highly combustible, as there is little economy to the householder in burning his dry waste; and, in fact, there is a greater quantity of this material available, but as it consists very largely of light rubbish, waste paper, boxes, etc., it is a question how its value as a fuel compares with that of more stable refuse, carrying even the average precentage of unburned coal. This is one of the many unknown factors in this problem.

The disposal of the residuum from crematory and destructor plants has been touched upon above. Crematory ashes, being fine and light, are not suitable to structural work, but in most cases have valuable fertilizing properties. Frequently, the sifting necessary to remove such foreign matter as tins, broken crockery, old metal, etc., absorbs what profit there might otherwise be in marketing them, but in localities where there is an active demand for the entire production, they can be profitably handled, or at least be made to bring in enough to pay for their disposal.

As the production of clinker from destructor plants is much heavier, its disposal is a proportionately more serious and difficult task. Being vitreous and entirely innocuous, if properly burned, this clinker is valuable material for making roads, mortar, concrete, paving flags, and even bricks; but, owing to the frequent lack of demand, does not always find a ready sale and often becomes such a burden that the city must pay to have it carted away. The little town of Bradford, for instance, spends $5000 a year for its removal.

It is estimated that if all of the clinker from existing destructor plants could be made use of, its value per annum would be $450,000 for brick and tile, or $200,000 for concrete, but the grinding, working and marketing of the material seems to be more of an enterprise than many cities are disposed, or fitted, to undertake.

Representative tests of the ultimate crushing strength of concrete made at the Bradford destructor plant show its value to be 128.03 tons per square foot for a mixture of Portland cement and destructor clinker 1:3. The highest value obtained for similar mixtures of granite, bluestone and Yorkshire stone concrete were respectively 199.64 T., 335.57 T. and 411.01 T. One sample of the

granite concrete ran as low as 85.1 T. per square foot. A general average of the stone concretes was 176.62 T.; of the clinker concrete 124.26 T. Clinker brick made of a 10 per cent. mixture of hydraulic lime were shown 50 per cent. stronger than ordinary building brick. The manufacturing cost of this clinker brick is said to be about $3.50 per thousand.

One of the most important advantages of the crematory and destructor systems is that of being able to locate the plant in practically any part of a city, without offense to its neighbors. The cost of installing the plant has to be met but once, while the expense of hauling material goes on forever. Every cent that can be saved, therefore, out of this fixed expense is well worth saving. Scores of cities are paying so much to have their garbage hauled out of the corporate limits, that for the same amounts they could install, operate and maintain crematory plants, which would pay for themselves in five or ten years. It has frequently been found that the entire expense of operating and maintaining a crematory near the center of population, and of collecting and delivering the garbage, is less than was formerly paid for hauling alone. An instance of this kind is the experience of Memphis, where four crematories were installed in different parts of the city, making the average haul probably not more than a mile.

The collection and cremation of the entire garbage production of the city, including labor and fuel at the crematories, is now accomplished at one-half the previous cost of hauling the garbage away and dumping it into the Mississippi.

The reasonable disposal of the special classes of refuse mentioned in the general ramification will be just touched upon before closing.

V. *Dead Animals.*—Bodies of large animals, especially horses, are frequently disposed of at a profit at rendering establishments, but when this cannot be done, they should be cremated, and cremated promptly. It is here that many cities are blameworthy, in failing to make prompt collections of dead animals, which become exceedingly offensive, particularly in warm weather, if not removed at once.

Burying is a suitable means of disposal in small places, but is not satisfactory for a town of any size, and incineration is commonly practiced.

V.' *Night-Soil.*—Nearly every city has a certain proportion of its residences outside of the district covered by its sewer system. The disposal of the excreta from these is an urgent problem. It cannot be safely thrown into waterways, is very offensive if cast

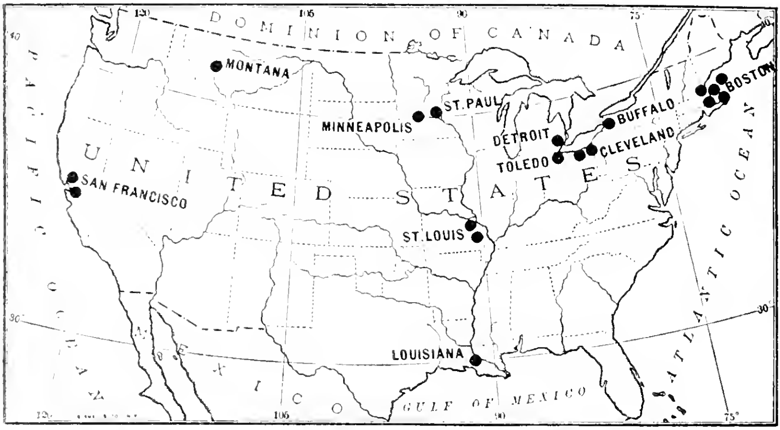
upon lands, impractical as a fertilizer, cannot be treated by the reduction process, and but one solution remains—the crematory.

VII. *Hospital Refuse.*—There can be little argument over this question. No sanitarian will deny that the proper treatment for such highly infectious refuse as is usually produced by hospitals, consisting not only of garbage, but bandages, amputated limbs, etc., is to destroy it by intense heat and preclude any possibility of spreading the infection.

VIII. *Trade Refuse.*—The question of disposing of this class of waste must be governed entirely by its physical character, which depends upon the process or manufacture of which it is a by-product. Sometimes of intrinsic value, again valueless, at others suitable only for a filler, it occasionally has a distinct fuel value, and may be utilized to good effect in supplementing the work of the regular power plant.

The disposal of sewage sludge is an open question: It is cremated with difficulty, and this does not appear to be the ideal method, at least in furnaces as now designed and operated.

As will readily be seen from the foregoing, this branch of engineering, at all events in the United States, is but in its infancy. Yet the importance of the work, in health to the public, in economy to the municipality, and its future possibilities, make it a subject which should appeal to every thoughtful and progressive engineer.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

Editors reprinting articles from this journal are requested to credit not only the JOURNAL, but also the Society before which such articles were read.

ASSOCIATION OF ENGINEERING SOCIETIES.

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THE MAIN INTERCEPTING SEWERS OF CLEVELAND, OHIO.

ADDRESS OF WALTER C. PARMLEY, RETIRING PRESIDENT OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read before the Club at its Annual Meeting, March 8, 1904.*]

OWING to the fact that almost from its very inception until the first of the present calendar year, your retiring President was intimately connected with the designing and constructing of the intercepting sewer system for the city of Cleveland, the present time and occasion seem opportune for rehearsing some of the history of this important undertaking and presenting some of the engineering features and problems connected with it.

Like all cities, Cleveland has had a sewerage problem of its own to solve. Part of the city lying upon comparatively level or very slightly rolling upland bordering on Lake Erie and part in the low-lying valley of the Cuyahoga River, which cuts the city from north to south into two portions, each of these parts presents a set of problems of its own, and from the standpoint of our intercepting sewer system a third and very serious problem by reason of the elevated portion of the city being thus divided.

The original city was in the valley, only slightly above the lake level, and upon the adjacent easterly plateau. As each portion grew and the necessity of sewerage arose, sewers were built according to the local need and leading by the most direct routes into the river or lake. Gradually there was thus developed a low-level area of sewers and a high-level area, each necessarily separate and distinct from the other. Finally, as the city developed metropolitan pro-

* Manuscript received August 1, 1904.—Secretary, Ass'n of Eng. Socs.

portions, the necessity of laying storm water mains became a pressing one, and old and undersized trunks were rebuilt or new sewers intersecting the lines of flow of the old sewers were so designed as to cut them into sections, thus relieving their congested condition. As illustrating this method of growth by bi-section and reconstruction, Erie Street is now provided with a sewer of the third generation, and the Woodland Avenue sewer, leading into it, was entirely rebuilt, cutting off other sewers, so that, for a large area, the sewerage has undergone an entire transformation. Then again, owing to the fact that the city has grown beyond the original plans in many drainage districts, new outlets have been located differently from what would have been the case if they had been designed in connection with the older portions. The result of all this is the fact that we have a river and a lake front both highly contaminated with sewage.

Sewers are discharged into the Cuyahoga River at frequent intervals along both sides, and, as the principal sources of pollution, slaughter houses, rendering works, and the refineries of the Standard Oil Co., are located along either the bank of the river or its tributaries there is produced a condition in the lower portion comparable with that of the Chicago River before the construction of the drainage canal.

For a distance of about five miles along the lake front, extending from west of the waterworks intake to Doan brook, large volumes of sewage are discharged into the shallow marginal water of the lake. Many years ago the dangers of such increasing pollution of the water front began to be recognized, and in 1882 Mr. Rudolph Hering reported to the Council a general scheme of intercepting sewers as the problem at that time presented itself. As the plan was not carried out immediately, the growth of the city made this plan obsolete, one principal feature only of it needing to be mentioned. This plan contemplated discharging the entire volume of the sewage into the lake at Marquette Street. That such a point of final discharge could at that time have been considered is one of the most surprising indications of Cleveland's growth and expansion in the last twenty years.

So urgent had become the necessity for the removal of the pollution from the river and lake front that in 1896, by action of the City Council, an expert commission was appointed to take up the whole subject of improved water supply and the disposal of the sewage of the city. The commission consisted of Messrs. Rudolph Hering of New York, Desmond Fitzgerald of Boston, and George H. Benzenberg of Milwaukee, together with Mr. M. E.

Rawson, then Chief Engineer of the Department of Public Works, and Mr. M. W. Kingsley, Superintendent of the Water Department. This commission was instructed to take up the subject thoroughly, to consider it in all its phases and to devise a scheme whereby pure lake water could be obtained as well as an efficient and permanent removal of the sewage.

Without going into a detailed discussion of the reasons on which they based their final report, a few of the principal objects to be accomplished and the physical conditions of the case may be stated. So long as the sewers were allowed to discharge directly into the lake, even a removal of the intake further from the shore would not insure an uncontaminated water supply, on account of the shallow depth on the margin of Lake Erie and the configuration of the coast line. The high winds, coming from the West, or North, or East, or any intermediate points, roile up the water with its accumulated sediment for several miles from shore. This sediment, being of course highly contaminated, injuriously affects the water supply. The Cuyahoga River being little more than a slack water inlet, the pollution from this source flows out directly toward the water works intake, and some means for removing the sewage from the river must be found.

It therefore seemed obvious that two principal things must be done: (1) to take the water supply at a point much further from shore; (2) to build an intercepting sewer system in such a manner as to intercept the sewage flow of all of the sewers of the city and carry it to some point of disposal so removed that the sewage would not contaminate the water supply. The third project, which was advocated by Mr. C. G. Force, Assistant Chief Engineer, was to build a flushing tunnel about 18 feet in diameter extending, from an intake on the lake shore near the eastern end of Edgewater Park, underneath the western portion of the city, to a point on the Cuyahoga River about 6 miles from its mouth; to erect a pumping station on the lake shore with a capacity sufficient to force a volume of water through this tunnel to the upper reaches of slack water in the Cuyahoga River, such that the entire volume contained in the river between the point of delivery and Lake Erie could be displaced every 24 hours. The expectation was that, if the volume of Cuyahoga River is displaced by a volume of comparatively pure water every 24 hours, its effect upon the water of Lake Erie would be much less deleterious than where it is allowed to stand for some days or even weeks in the river channel before its final discharge. The expense of carrying out this project seemed to be the most serious objection against it, as the cost, for the tunnel, the pumping

station and the necessary terminal works was estimated to be about $1,000,000.

The final recommendation of the commission was to the effect that the water supply should be taken from a point in Lake Erie about 4 miles from shore and as far to the west of the mouth of Cuyahoga River as practical; that the intercepting sewer be so devised as to carry as much of the sewage of the city as possible by gravity to a common outlet about 10 miles to the east of a point on shore opposite the water works intake. It further recommended low level intercepting sewers for all of the valley lying along the Cuyahoga River and its branches; that is, that Walworth run, Morgan run, and Kingsbury run, lying below the level of the gravity system be sewered to convenient pumping stations and there be lifted to the high level system and thus delivered to the one common outlet for the entire city. The sewer commission was divided in regard to the flushing tunnel project; the majority advocating its immediate construction, but the minority reporting in favor of first constructing the water intake system and the intercepting sewer system. It was the belief of the minority that taking the water supply at a greater distance from shore and discharging the sewage into the lake as far to the east as possible would render the construction of the flushing tunnel unnecessary. If, however, this did not prove to be the case, they recommended that the flushing tunnel be then built. As up to the present time nothing has been done toward building the low-level intercepting sewers, I shall dismiss this part of the subject and confine myself entirely to the high level or gravity system.

Following the advice of the commission, the City Council determined to enter upon the construction of high-level intercepting sewers. They established a department of special sanitation, and, as engineer in charge of this department, I have given the past seven and one-half years to the development of the system. While the work is not all constructed, so much has already been designed and built, sizes, grade elevations and the engineering lines permanently fixed, on which the entire work must be carried through to completion, that no great modification can hereafter be made either in that which has been done or in that which is planned.

The commission planned the building of a large interceptor to extend entirely across the lake front of the city, beginning at the western limits at Highland Avenue, and extending eastward so as to intercept the flow from all of the sewers of the west side which discharge into Lake Erie, passing underneath the Cuyahoga valley and river through an inverted syphon about three-quarters of a mile

in length, extending easterly along Lake Street and through streets parallel to the lake, and discharging into Lake Erie some eight miles east of the Cuyahoga River. A branch, extending south from the main interceptor at Ross Street and passing through the entire length of Perry Street to the intersection of Broadway, was contemplated. At this point it was to branch again, one portion extending across the Cuyahoga valley and river in a southwesterly direction through another inverted syphon nearly a mile in length, terminating near the southern end of the Central viaduct. From this point it will extend in a southwesterly direction to about the intersection of Walworth Street and Barber Avenue, at which point it will intercept all of the branches flowing into Walworth run.

The other branch, from the intersection of Broadway and Perry Street, was to extend along Pittsburg road, crossing the Kingsbury valley through inverted syphons, and pass out Broadway to Petrie Street, where it would continue to the south, cutting the drainage of Morgan run and ultimately that of Burke brook still further to the south. A branch was to extend from this lateral to the eastward along the north side of Kingsbury run valley, and terminate at a point about a half mile east of Willson Avenue, taking in numerous sewers en route and at the latter point intercepting the flow from all the upper portion of Kingsbury run.

The commission had laid down some of the different ideas which were to control the construction of the intercepting system, but it left all matters of their development and details to be determined by further study. As a result of this further study, an important lateral begins where the main interceptor crosses Doan brook, and extends in a southeasterly direction along Doan brook valley a distance of about four miles to Cedar Avenue. This sewer, known as the Doan valley interceptor, is the outlet for all of the important and rapidly growing eastern portion of the city.

The map [Fig. 1] shows the main drainage areas which are tributary to the several portions of the high level interceptor and its branches. It is thus seen that the entire city is drained, with the exception of a comparatively small part lying along the valleys. It was, therefore, recommended that the low-level system be not constructed until after the building of the high-level system.

The commission fixed the unit volume of sewage discharge to be employed in designing the system. It was assumed that the maximum rate of flow per capita would be 200 gallons, and, in order to prevent the first and most filthy of the gutter water from the streets discharging into Lake Erie by way of the storm-water overflows, the sewer, as designed for the above unit, should never run more

than half full, the upper half of the sewer being reserved for this first surface flow from the street. It was further assumed that, within the next 25 or 30 years, the population of Cleveland would reach 1,000,000, and the size of the sewer was therefore made sufficient to accommodate this population.

The grade inclination of the main interceptor was fixed at 2 feet per mile, and the commission was undecided as to whether the

FIG. 1. MAP OF CLEVELAND, SHOWING PRINCIPAL AREAS TRIBUTARY TO THE MAIN INTERCEPTING SEWER.

Space within shaded lines indicates area tributary to low-level system.
Arrow-heads indicate the most important inlets to Intercepting Sewer.

elevation of the center of the outlet should be 7.5 feet or 10 feet above base. They recommended that the main outlet be 13 feet in diameter, but, owing to subsequent study of the case and the fact that a considerable area lying still further to the east from that considered by the commission will become tributary to the sewer, the diameter, from Doan brook easterly to the outlet, was increased to 13 feet 6 inches. The elevation of the outlet, as finally determined, is 7.75 feet above base for the center of the sewer, or, 1 foot above base for the invert.

The final location for the intercepting sewer was not determined by the commission. It was expected, however, that the portion east of the river would run along Lake Street to Marquette Street, thence either along the right of way of the Lake Shore and Michigan Southern Railway easterly, or, by some other direct location to be secured, to Ansel Avenue. After crossing Doan brook, it was to follow the Lake Shore boulevard to the outlet, which was expected to be a short distance east of Euclid Beach Park. It was found subsequently that the sewage outlet could not be made quite so far to the eastward, and a tract of about 6 acres, on the shore of the lake at the foot of Adams Avenue in Collinwood, was purchased by the city for outlet works. This point is distant from the Cuyahoga River about 8½ miles.

It was found later that certain changes would be necessary in the location. On account of the great cost of the work per lineal foot, as direct a route as possible was desirable. Negotiations were therefore begun with the Lake Shore Railroad, which finally resulted in an agreement whereby the city obtained the right of way along the northern portion of their right of way and extending easterly from Gordon Park to a point about 1950 feet east of Doan Street, a total distance of about 6000 feet. The consideration for these rights was $13,986.52.

Another important change was made easterly from this latter point. It was found that, where the sewer would cross Nine Mile creek at the Lake Shore boulevard, expensive retaining walls would have to be constructed, and this, together with the almost certain litigation with adjacent property owners, which would result if it were attempted to build a sewer by this route, caused the city to seek a new location. Additional rights were therefore secured from the railroad, extending easterly from the right of way already acquired and over adjacent land parallel with the railroad, to where Gilbert Street meets Coit Avenue, immediately to the north of the railway. From this point, rights were obtained to the east and north in Gilbert Street to an intersection with the Lake Shore boulevard.

In obtaining this location it was necessary to enter into an agreement with the village of Collinwood, and to obtain a modification of the terms of the original contract between the city of Cleveland and the village of Collinwood. By this contract, in consideration for the right of way, the city of Cleveland agreed to construct, and to allow the village of Collinwood the exclusive use of, one of the terminal discharge pipes into Lake Erie. The village insisted upon this concession because their sewage plane is about ten feet lower than that of the city of Cleveland, and, if the two flow-lines

are not kept separate, the sewage of the main intercepting sewer would flow back and flood the sewers of Collinwood. Although the cost of building the $3\frac{1}{2}$ or 4-foot pipe line into Lake Erie, thus made necessary, would involve extra expense, it seemed the only practicable thing to do. By this location the length of sewer was increased some 930 feet over the location by way of the boulevard. Up to the present time I see no reason to regret the selection of this route, but, as will be noted further on, subsequent experience in the construction of the sewer has shown that it would have been more economical for the city to purchase a right of way parallel and adjacent to the railway on the north side than to have attempted to build the sewer on land owned by the railway and under a contract whereby the railway could impose conditions upon the city in the construction of the sewer.

The first and most important item, in connection with carrying out of the intercepting project, was the building of the sewer in Walworth run, which is technically more a main storm sewer than a portion of the interceptor at all. Plans were therefore first perfected for this portion of the work, which was under actual construction from early in 1897 until the spring of 1903, and upon which, although in cost exceeding $800,000, the final settlements have not yet been made. It is not necessary, however, at this time, to describe this work in detail as it has already been discussed before this Club.

On account of the urgent need in the western portion of the city, which had formerly been the village of West Cleveland, and which territory was dependent upon the construction of the intercepting sewer for its outlets, it was determined to build the western extremity of the interceptor first. Here the location under agreement followed the Lake Shore Railroad for a distance of about 4000 feet from Alger Street to Lake Avenue. The diameter of this section of sewer is from 6 feet to 8 feet. This section was built during the season of 1897 by Louis Fahey, at a cost of about $30,000. During 1898 and 1899 the interceptor was continued westerly along Lake Avenue as far as Lower Street.

There are no interesting features in regard to the construction of the sewer itself. At the intersection of Lake Avenue and the Lake Shore Railroad, however, the Desmond Street trunk sewer, the Lake Avenue sewer from the east, and the intercepting sewer from the west, converge. The problem of the separation of the sewage from the storm flow became quite complicated, as will be seen by the plans (Fig. 2). The portion of the interceptor west of the railroad carries the full volume of storm water as well as of

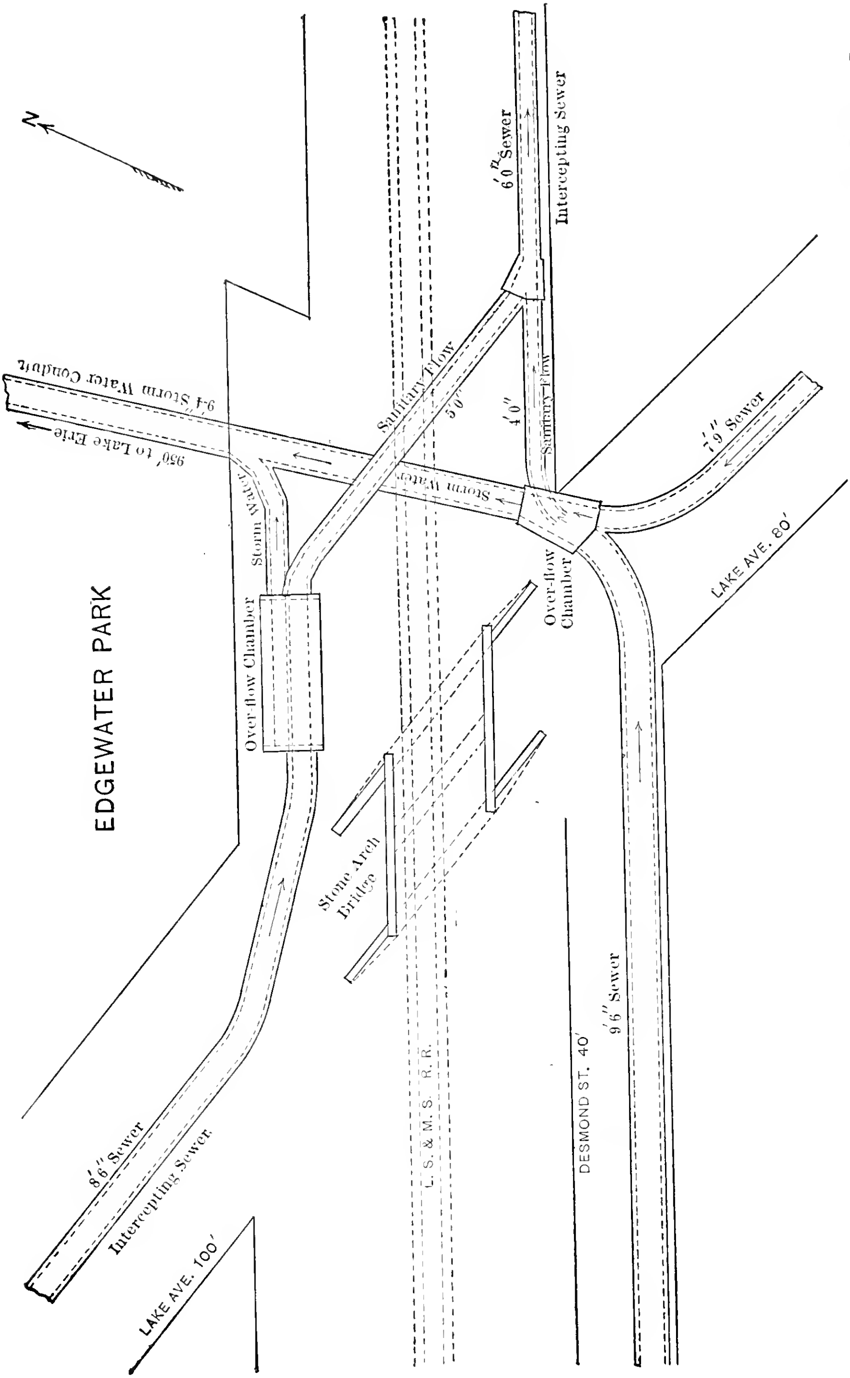

Fig. 2. Location of Storm-water Overflows and Sanitary Flow Sewers at the Intersection of the L. S. & M. S. R. R. and Lake Avenue.

sewage, and at the points of intersection of this portion with the main sewer in Lake Avenue from the east, and with the Desmond Street sewer, overflows were constructed in such a manner that the flood water would pass through a 9-foot 4-inch storm-water outlet tunnel underneath Edgewater Park and discharge into Lake Erie. Where the Desmond Street sewer and the Lake Avenue sewer east of the railway intersect, a chamber junction was built, and the invert provided with a deflecting weir or dam in such manner that the sewage is carried through the side of the structure into the intercepting sewer, the flood waters passing over the dam and down a steep incline into the Edgewater tunnel. The diameters of the Desmond Street and Lake Avenue sewers are respectively 9 feet 6 inches and 8 feet 6 inches.

The overflow from the interceptor, in Lake Avenue west of the railroad, is so constructed that the sewage passes through a 5-foot tunnel diagonally underneath the embankment of the railroad, joining with the interceptor about 100 feet down stream from the chamber junction first described. Where the flow comes into the chamber the sewer is 8 feet 3 inches in diameter, and the storm water flows sideways over a weir 50 feet in length, passing down the storm overflow channel into the Edgewater tunnel. The tunnel, conveying sewage from this chamber to the main intercepting sewer through and underneath the railroad, passes diagonally over the inclined portion of the Edgewater tunnel where it approaches the chamber junction on the Desmond Street sewer.

The portion of the Edgewater tunnel underneath the railway was built under one of the Louis Fahey contracts in 1898. The tunnel was in very wet, treacherous quicksands, and was built with great difficulty, and, in order to prevent serious settlement of the railway, large masses of brick masonry were built into the cavities and pockets that formed over the arch. The network of trunk and intercepting sewers, converging at this point, was completed about 1900. The complicated sewer connections at this point are well illustrated by the plans.

A short extension of the intercepting sewer between Alger Street and Gordon Avenue was constructed in 1898, together with an overflow sewer extending down Gordon Avenue to the Lake Shore Railroad, following easterly along the Lake Shore and Michigan Southern Railway to Waverly Street, at which point it turns to the north and empties into the west basin of the harbor. At the west side of Gordon Avenue an overflow chamber, similar to the one on the Lake Avenue section just described, was built. The cost of the portion of the intercepting sewer system from Gordon Avenue west was about $200,000.

It will be noted that I have described storm-water overflows from the intercepting sewer. An intercepting sewer, strictly speaking, should have no storm-water overflows. The reason for this may readily be seen by considering the fact that, if combined sewage and storm water were to be discharged into an intercepting sewer of indefinite length, overflows being provided at those points where the sewer would be liable to surcharge, a point would soon be reached where there would be no difference in composition between the sewage contained in the intercepting sewer and that flowing in from the lateral mains. Since, however, the west side sewers are near the upper end of the intercepting system, the effect of storm overflows directly from the interceptor is not as objectionable as they would be nearer the outlet. It was, however, determined that, at no point in the system east from Gordon Avenue, would overflows be constructed.

To avoid the objectionable overflow of sewage from the interceptor, the overflow chambers are built on the combined sewers before the connection with the interceptor is made. Hence, only the sewage of the storm sewers, together with the proper ratio of street washings, is allowed to enter the main intercepting sewer, and the sewage, when once in the interceptor, is there confined until it reaches the final outlet. In this manner only will the interceptor truly intercept the sewage, and in the best manner prevent the pollution of the water front.

It was not until the autumn of 1900 that the work of designing the main interceptor outlet was begun in earnest. Plans for four different sections were developed during the winter and spring of 1900-1, and contracts were let in the summer of 1901. The first contract to be awarded was that extending from the point on the shore of Lake Erie off Adams Avenue, upon land purchased by the city for the terminal, and extending westerly along the lake shore a distance of about half a mile to Gilbert Street.

In view of the rapid increase in price of labor as well as all of the materials used in sewer construction, I gave considerable study to determining the most economical construction for this work. At best, the outlay would be enormous, but even a small percentage of saving in the aggregate would represent many thousand dollars of saving to the city. A concrete and steel structure was finally decided upon, but plans were also made for a concrete brick-lined section, and bids were invited upon each. Fig. 3 shows the location, profile, and sections of these structures. The bids were received on June 25, 1901, the lowest bid for the masonry section being $108,630.28 and that for the concrete and steel section $85,025.84, a resulting

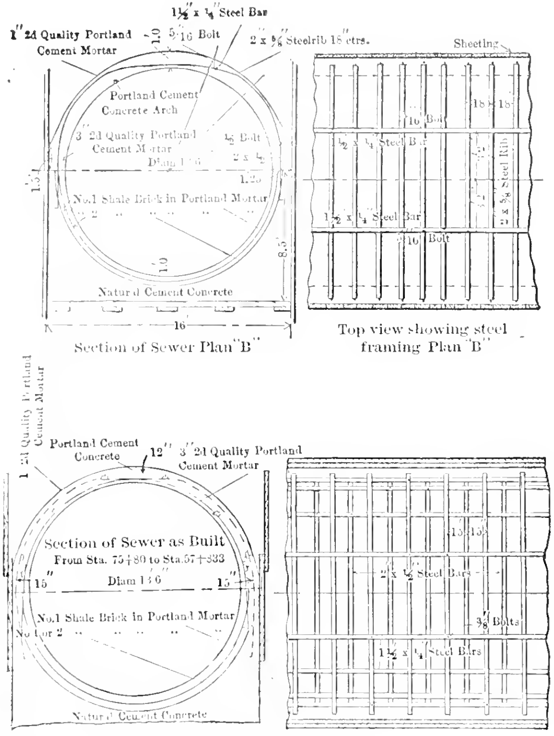

FIG. 4. OUTLET SECTION.

APPROXIMATE QUANTITIES PER FOOT OF SEWER.

Brickwork	0.63	cu. yd.
Portland Cement Concrete	0.90	"
Natural Cement Concrete	1.65	"
Excavation	14	"
Iron and Steel	82	lbs.
Grillage	63	ft. B. M.
Sheeting and Bracing	135	" "

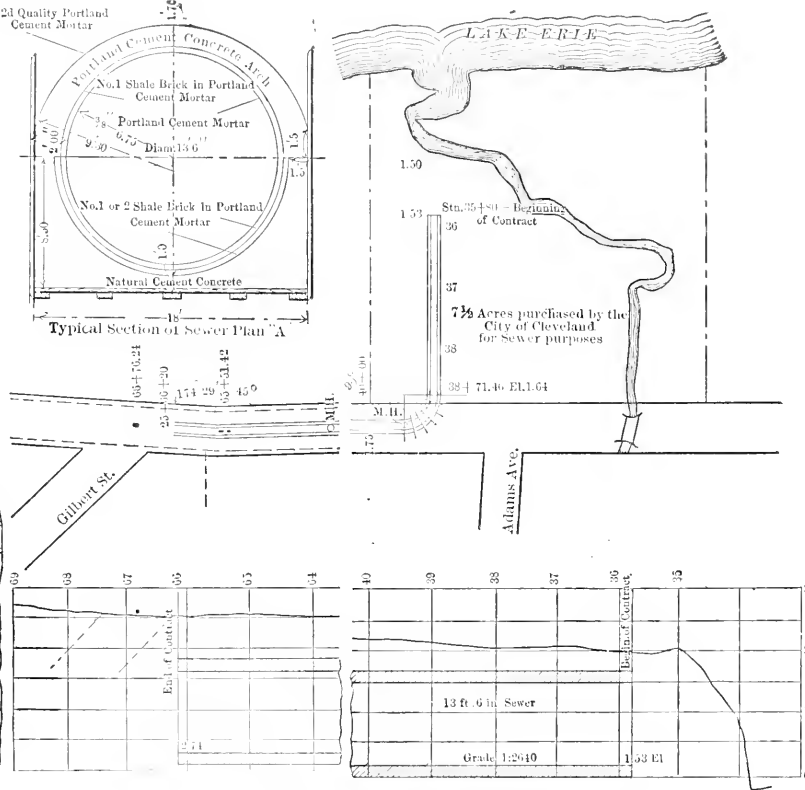

FIG. 3. OUTLET SECTION.

APPROXIMATE QUANTITIES PER FOOT OF SEWER.

Brickwork	0.932	cu. yd.
Portland Cement Concrete	1.74	"
Natural Cement Concrete	2.55	"
Excavation	17	"
Grillage	69	ft. B. M.
Sheeting and Bracing	135	" "

saving, in the cost of the concrete and steel section over that of the masonry section, of nearly 22 per cent.

The work was accordingly let to Messrs. Beers & Doolittle for the concrete and steel sewer; but, on account of delays in executing the contract and getting machinery ready, the date of beginning of the actual construction of the sewer was April of 1902.

So successful had been the result of the bidding upon the first section of the work, that a similar method was followed in the letting of the next two sections. These sections were not continuous with that first let, for the reason that there was some uncertainty as to the right of way for the portion immediately to the west of the Beers & Doolittle contract. The second bids therefore were for the portion extending from a point on the Lake Shore and Michigan Southern Railway from Doan Street to a point 1750 feet easterly. The plan of the sewer was the same as that shown in Fig. 3, but the depth of excavation in places was over 40 feet. Bids for this work were received July 2, 1901. The lowest bids were made by Mr. Christian Burkhardt, at $103,297 for masonry construction, and $80,131 for the concrete and steel; the difference being $23,166, or a saving of over 22 per cent. The bids were received for the next section, extending from Doan Street westerly to Lewis Street, on a section where the excavation was all from about 38 feet to 44 feet deep. The figures of J. Connelly & Son the lowest bidders, in this instance, were $128,891 for the concrete and steel as against $160,498 for the masonry structure, or, a saving of about 19.7 per cent. Contracts were accordingly awarded to these firms on a basis of the concrete and steel structure. Later, however, the concrete and steel section, with the consent of the contractors, was changed to that shown in Fig. 4, in which a more complete inner and outer metal skeleton was provided.

The fourth section for which bids were received was a continuation of the sewer westerly from Lewis Street and across Doan brook valley to Ansel Avenue. As the saving in the cost of the work, by adopting concrete and steel, was so great, it was decided not to receive bids for masonry structures at all. Plans and specifications were then based entirely upon concrete and steel similar to that already contracted for, and the work was accordingly awarded to the Clements Construction Co. upon bids received July 16, 1901, for $176,190. The beginning of the construction work on all of these sections was delayed until the spring of 1902 in a similar manner to that on the Beers & Doolittle contract.

The final location of the right of way having been determined, and in order to hasten the completion of the portion of the main

interceptor from Doan brook to the outlet, during the spring and summer of 1902, four other contracts were awarded, viz, to the Clements Construction Co. for the portion on Gilbert Street from the Lake Shore boulevard to Shipherd Street; to Beers & Doolittle on Gilbert Street and along the Lake Shore Railway from Shipherd Street to Coit Avenue; to Messrs. J. Connelly & Son along the

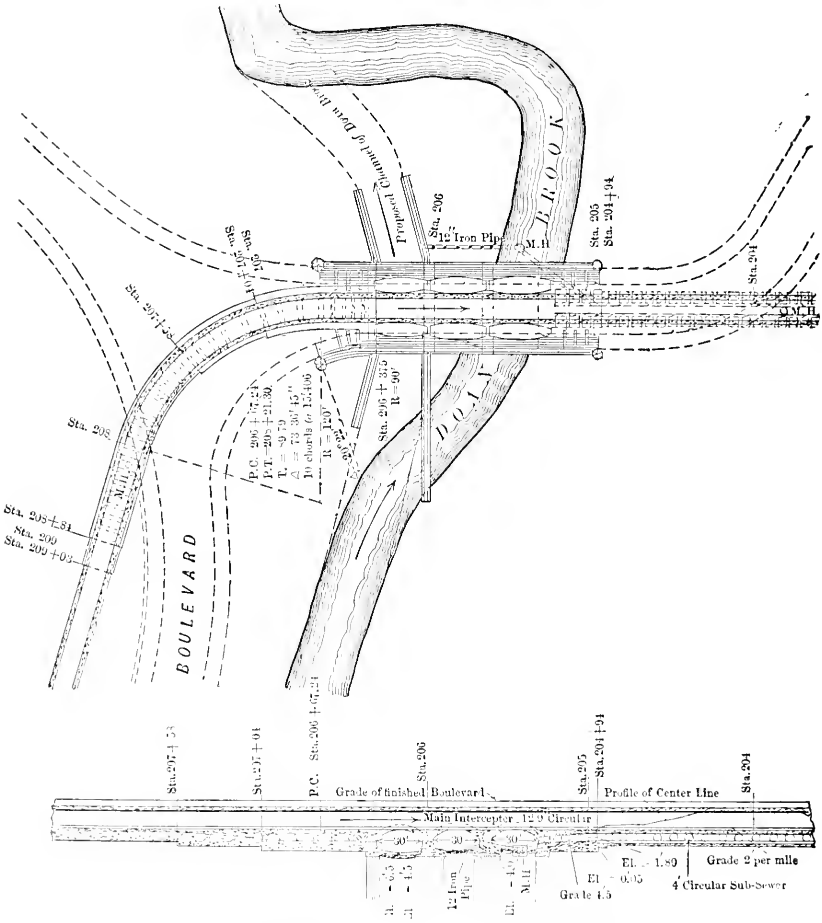

FIG. 5. DOAN VALLEY CROSSING OF MAIN INTERCEPTOR.
Scale 1 = 1440.

Lake Shore Railroad from Coit Avenue to Eddy Road, and to John Wagner & Son from Eddy Road west to a point 1750 feet east of Doan Street connecting on to the portion of the work awarded to Burkhardt. These four contracts were for concrete and steel sewers, and the aggregate bids were about $434,000. During the season of 1903 work was prosecuted upon all of these sections with the excep-

tion of the Burkhardt contract, resulting at the present time in almost completing the first Beers & Doolittle contract on the Lake Shore boulevard and the practical completion of their second section from Shipherd Avenue to Coit Avenue, including the Nine Mile creek syphon, and the entire completion of the Clement contract on Gilbert Avenue from the boulevard to Shipherd Avenue;—the other sections being in a partial state of completion.

The section from Lewis Avenue to Ansel Avenue was located and contracted for by way of the route passing across the valley on the south side of the Lake Shore and Michigan Southern Railway. Before construction was actually begun, however, the chief engineer decided that it would be advantageous to build the sewer upon the north side of the railway, and accordingly issued instructions to the contractor to follow the new location upon that side.

In the meantime, on September 1, 1902, Cleveland experienced a phenomenal downpour of rain, said to have been the heaviest in 40 years. In consequence of this fact and the necessity made apparent for ample water way, the culvert for Doan brook, which passes underneath the intercepting sewer, was greatly increased from what was first contemplated. The capacity of the culvert, as finally designed and built, is for 3000 cubic feet of water per second. The culvert consists of three 30-foot water ways, spanned by 3 parabolic arches with low abutments. The arrangement of the lower driveways of Gordon Park is such that one of the boulevards passes from the west side to the east side of the valley across and on top of the sewer structure. The culverts are therefore made 60 feet long, terminating in substantial and ornamental parapet walls, buttresses and copings. Fig. 5 shows the general plan of this work, and Fig. 6 a view during construction.

The grade line of the interceptor is several feet above the bottom of Doan brook valley, and it was therefore necessary to carry the foundations down to solid clay. Transverse circular forms were imbedded in the foundation, thus reducing the amount of concrete required, and at the same time decreasing the pressure per square foot upon the clay. This portion of the work is practically completed and is well shown by the plan, Fig. 5, and by Figs. 17A, 17B and 17C.

An interesting feature experienced may be mentioned in connection with these culvert arches. The parapet walls are stone faced, with Portland cement concrete backing, and with anchor rods embedded. The arches themselves, however, consist of unarmored concrete. After the filling for the boulevard was deposited on each side of the sewer and inside of the parapet walls, it was noticed, in

several of the arches, that there was a slight tipping out of the parapet walls, resulting in a crack running around the arch parallel to the face and about 6 or 8 feet back from it. This doubtless resulted from the fact that the weight of the parapet wall is greater than that of the earth backing, and caused a corresponding increase in the deflection of the arch at the ends. The outward pressure of the earth backing tended in the same manner to push the parapet out and so produce a crack. As soon as this was discovered,

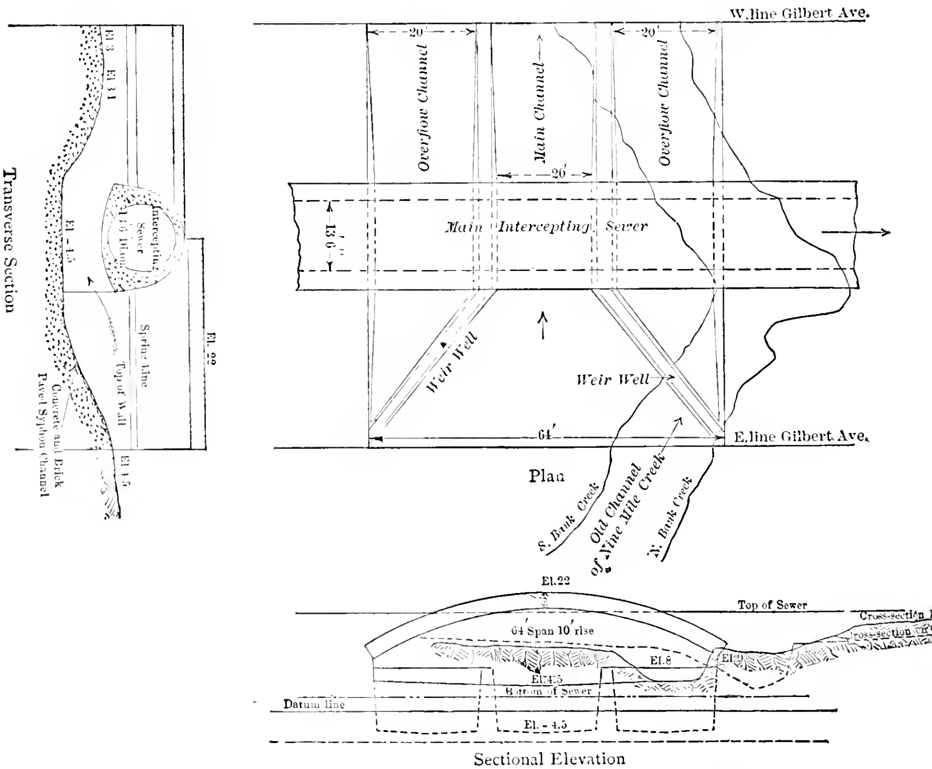

FIG. 7. MAIN INTERCEPTING SEWER CROSSING AT NINE-MILE CREEK.

channels, at right angles to the face of the arch, were cut in the intrades. These channels were cut about 3 inches wide and 2 inches deep and were about 6 feet long. In these channels were imbedded ½ inch x 2 inch steel bars in Portland cement mortar. Seven such bars were built into each end of the arches, and it is believed that no further damage will result.

Another interesting detail occurs where the sewer crosses Nine Mile creek, as shown in Fig. 7, which gives the plan of the intersection. The grade line of the sewer is about on a level with the

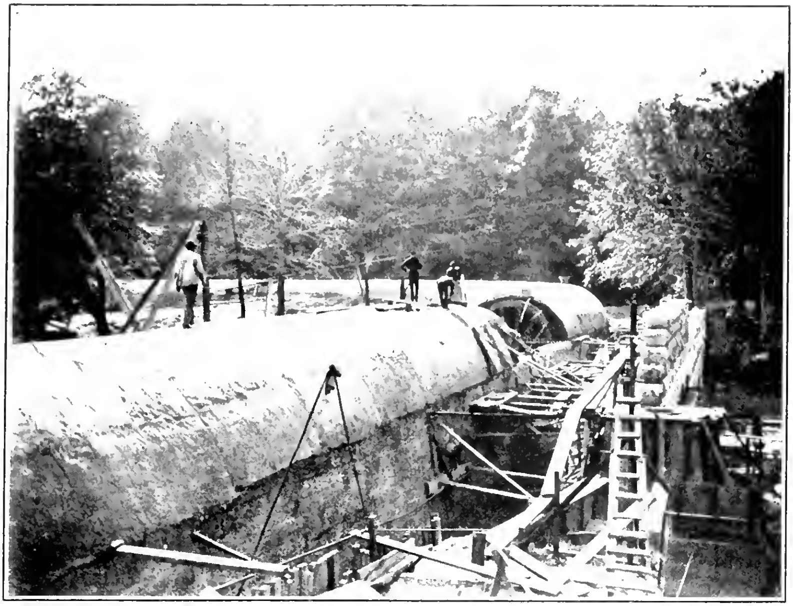

Fig. 6. Showing 12′ 9″ Main Intercepting Sewer Crossing Doan Brook Valley. Park Boulevard is Carried Across the Valley on Top of the Sewer.

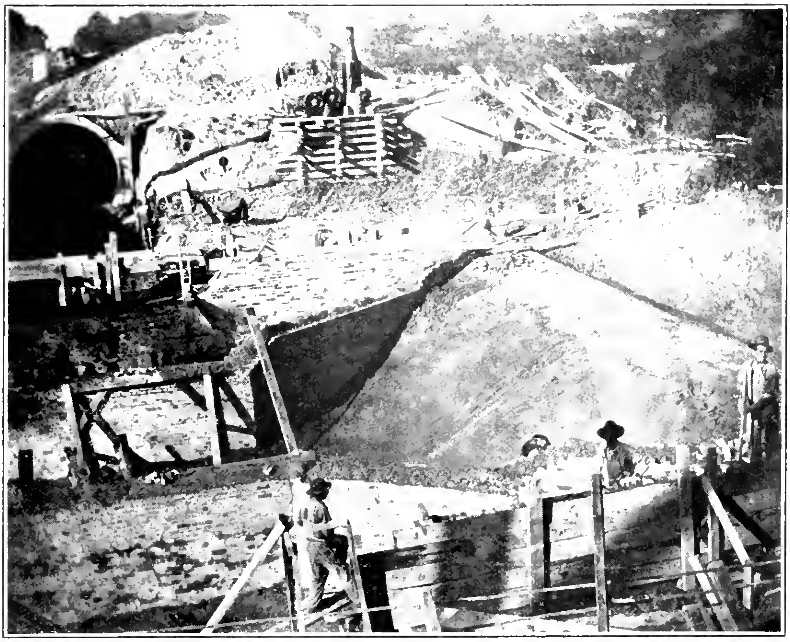

Fig. 8. Showing Channel of Approach to Nine-Mile Creek Inverted Siphon.

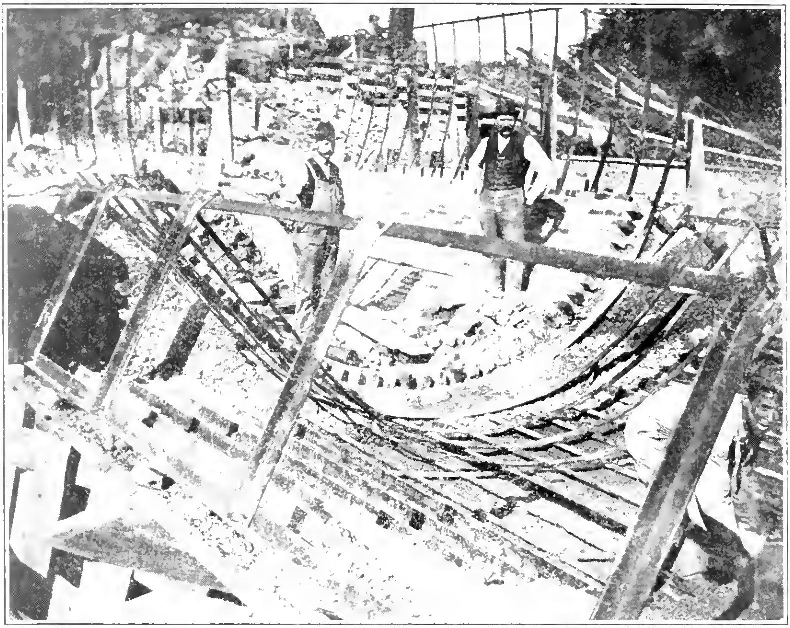

Fig. 9. Showing Tubular Bridge Construction of 13' 6" Sewer at Nine-Mile Creek Crossing.

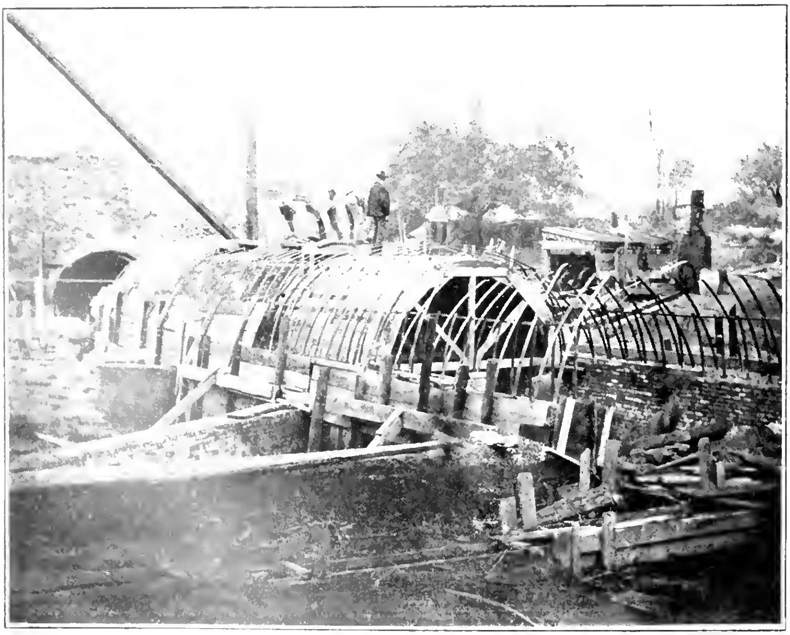

Fig. 10. Showing 13' 6" Sewer Passing over Nine Mile Creek.

channel of the brook, and it was therefore necessary to carry the brook underneath the sewer in an inverted syphon. Three 20-foot channel ways were provided. At the inflow end, however, oblique walls, extending diagonally across the two side channels, are constructed in such a manner as to converge all of the flow through the middle channel, except during excessive floods, when the water will flow over the oblique walls into the two side passageways.

On the down stream side the water is allowed to pass through each channel separately. The whole structure is made 80 feet long in order to extend the entire width of Gilbert Street, and on the down stream side is arched over with three 20-foot concrete and steel arches. On the up-stream side it was necessary to build a single-span arch of about 80-foot span, between abutments, in order to avoid obstructions to the inflowing water. Along the up-stream and down-stream lines of Gilbert Avenue, the structure terminates in parapet walls to confine the earth filling which is used to bring the street up to grade.

Steel being imbedded in the bottom portion, to form a lower chord to the structure, and the sewer being completely hooped with steel, it cannot deflect under the weight of the water inside, or the pressure of the earth from without. It thus becomes practically a tubular bridge. The plan, Fig. 7, clearly illustrates this work and it is further shown in the photographs, Figs. 8, 9 and 10. A similar method is adopted for sustaining the interceptor where it crosses Dugway brook, but in this instance the inverted syphon was not necessary.

As already stated, the work of actual construction of the intercepting sewer, east of the river, did not begin until April, 1902, the point of beginning being near the outlet upon land owned by the city.

Some time, of course, was occupied in excavating the trench to the necessary depth, and in connection with this work an interesting thing happened. The ground is a clay which stood with vertical banks until, for a length of something like 300 feet, the excavation had been nearly completed. No sheeting or bracing had been used, as the excavation had been done by means of teams and scrapers with inclines at the ends. At about this time a three days' steady rain occurred, soaking the banks so that they began to cave. Sheeting and bracing were inserted as quickly as possible, but not until the banks squeezed together so as to make it impossible to build the side walls of the thickness planned. On account of the difficulty and cost of setting the sheeting back to the necessary line, the contractors were permitted to proceed with the building of the sewer, with the side walls much thinner than the contract called for, and with the

expectation that afterwards they would dig down on the outside, remove the sheeting and reinforce the sewer. As the contractor's force of men was busy with construction work, this reinforcing was not done immediately, and, with the exception of one small portion, it has not yet been done. Fig. 11 shows actual cross sections of the sewer as it was built and as it is standing to-day, carrying the load (one exception to be noted), without a sign of cracking or weakness. It will be observed that, in many places, the side wall is only 6 inches thick or even less, and the fact that it is holding the earth loads of a 20-foot ditch is a striking proof of the strength of the concrete and steel structure. On the west side of the sewer near the outlet there is one place about 30 feet long, where the brickwork opened along the underside of the top course of brickwork and just below the springing line of the arch. As the width of the invert is somewhat less than 13 feet 6 inches, an examination shows that it

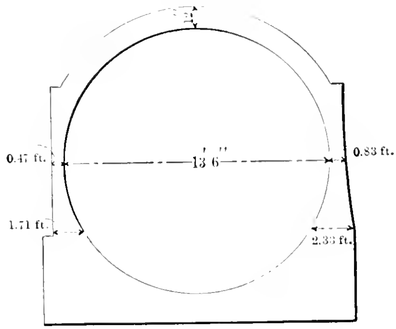

Fig. 11. Cross Section of Intercepting Sewer.

resulted from the side pressure of the earth forcing in the thin side wall either during or immediately following the construction of the arch and before the centering was removed. As the normal tendency is for the sewer to increase in width at the springing line instead of to diminish, its behavior is evidently due to a weakness of the side wall below the springing line and not to weakness in the arch structure itself.

The general method pursued by the contractors varied only in matters of detail. For the most part cable machinery is used upon the work. The excavation is carried to the required depth and made level transversely. The concrete foundation is then laid, with the proper curve at the bottom, and is carried up to about the level of the bottom ends of the anchor bars. The brick lining is then brought up to about the same level. The anchor bars are suspended to line and grade and to the proper spacing. To accomplish this,

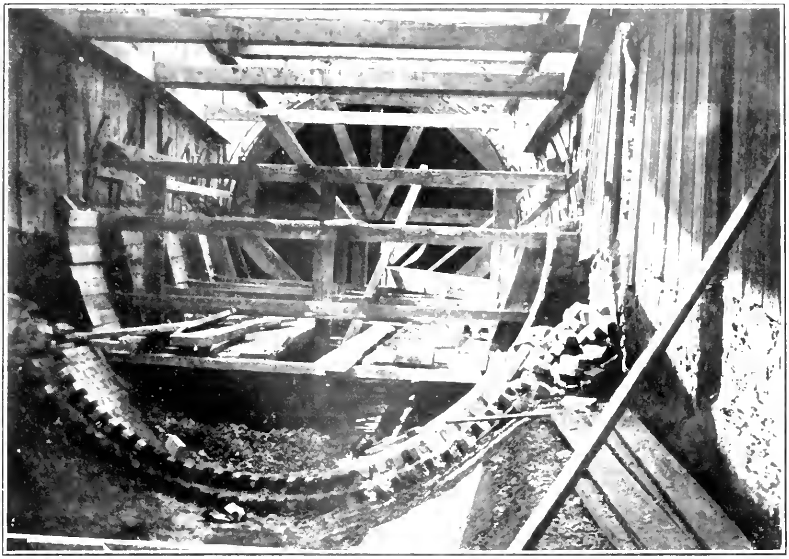

Fig. 12. Showing Formation of Invert and Side Walls of 13′ 6″ Sewer.

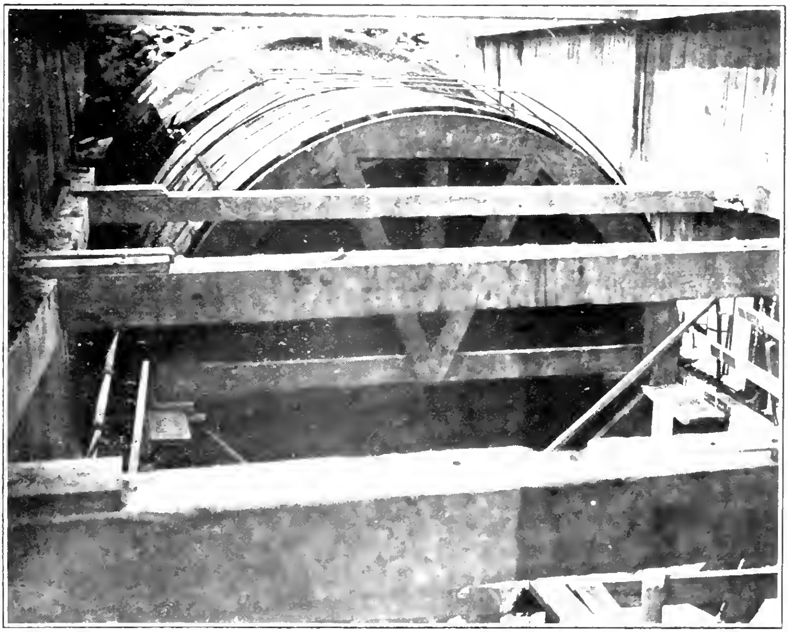

Fig. 13. Arch Skeleton of 13′ 6″ Sewer.

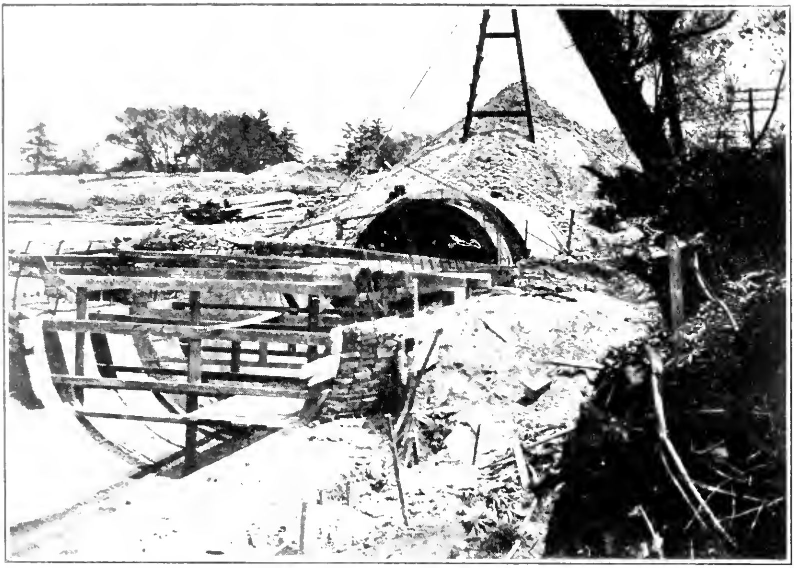

FIG. 14. 13′ 6″ SEWER IN SHALLOW TRENCH AND IN DIFFERENT STAGES OF COMPLETION.

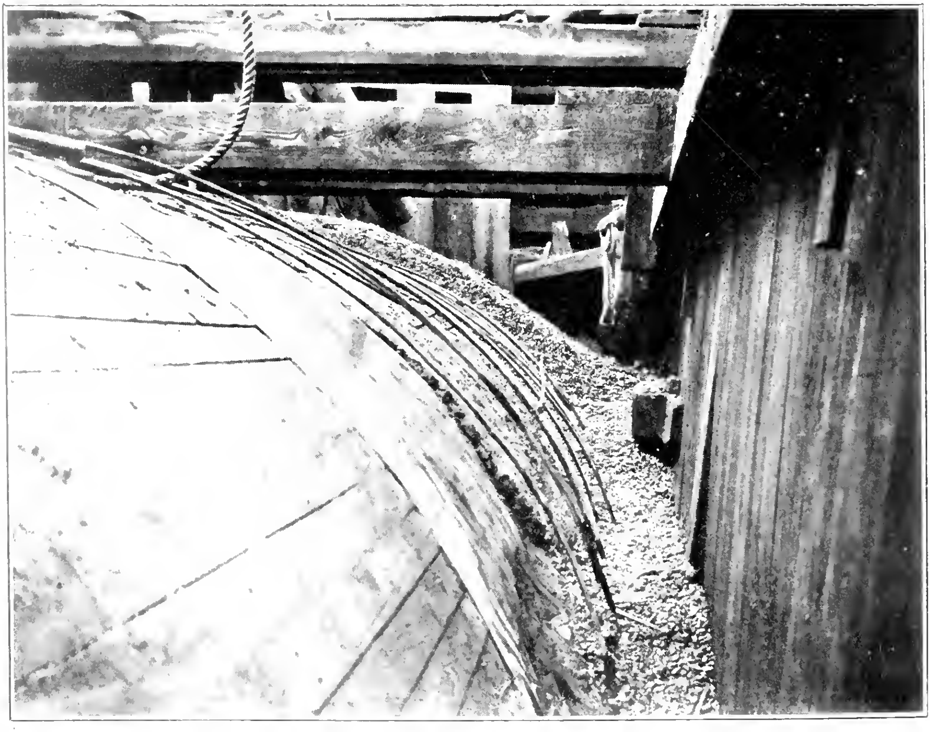

FIG. 15. 13′ 6″ SEWER WITH SKELETON OF ROUND RODS.

FIG. 16. 13′ 6″ SEWER, 40 FEET DEEP.

the anchor bars are either bolted temporarily to longitudinal 2 inch x 4 inch scantlings or to the longitudinal side bars which are supported at the proper line and grade.

The brick lining of the sewer, at the side and above the lower ends of the anchor bars, is now laid, and the concrete backing is rammed in place as the brickwork progresses, or, as preferred by some contractors, the concrete backing is built a day in advance of the brickwork, behind special forms. As soon as the side walls are built up to the springing line and have had about twenty-four hours' time to harden, the centering for the arches is erected. This centering is now covered with a layer of building paper, treated with oil or paraffine. The main arch bars are then coupled to the upper ends of the projecting anchor bars, and the longitudinal bars, provided for by the plan, are bolted or wired in place as the case may be. Portland cement concrete, made quite soft so as to require but little ramming, is deposited so as to fill the entire space between the centering and the side of the ditch, or against the plank sheeting, care being taken, however, to keep a thick layer of mortar immediately against the paper lining. The arch structure is thus carried up against the sheeting at the sides, for a distance of 15 inches above the springing line. At this point a plank is braced against the side of the ditch in such manner as to form the extrados of the arch, tangent to the curved upper portion. The remainder of the arch work is carried on and completed without the use of any exterior forms. A half-inch layer of Portland cement mortar is then applied to the entire extrados, and the mortar is allowed to take its initial set before back filling is begun. Back filling is deposited at the sides, care being taken not to injure the freshly built arch, and no dumping from the cable buckets is allowed upon the arch until the back filling has been deposited for a thickness of two or three feet over the back. Figs. 12, 13 and 14 are typical views of different parts of the sewer during construction.

Since the back filling begins while the concrete of the arch is still soft, or before it has gained any considerable strength, it is absolutely necessary to have good centering in this kind of work. The need of hard wood wedges, and of having the braces or legs which carry the arch ribs supported, spiked, or bolted together so as to absolutely prevent settlement or spreading, is of the greatest importance. A failure of some of the contractor's foremen to attend to these matters, has caused damage to certain arches, but in no case, where these details were properly attended to, has the least trouble occurred. The arches as completed have shown themselves to be stronger than could be anticipated were they built entirely of brick

masonry. The total deflection vertically of the 13-foot 6-inch sewers, built in wet trenches forty feet or more in depth, does not exceed $\frac{1}{2}$ inch, and the increase in horizontal width of the sewer does not exceed $\frac{3}{4}$ inch. These deformations are not more than half of what I have frequently observed in brick sewers having less diameter.

With one exception the plan of steel work used on the other sections is the same as that employed upon the first Beers & Doolittle contract. The steel skeleton for the Clement's contract on Gilbert Street, between Shipherd Avenue and the Lake Shore boulevard, consists of round rods instead of flat bars. This section is a very fine piece of workmanship, but on the whole I am inclined to believe that flat bars are preferable to the round ones, as they can be held more rigidly in place while being imbedded, and they also present, for a given sectional area, a greater surface of contact between the steel and the concrete. Fig. 15 is a view of a portion of this work. On this contract the excavation was made with a Vulcan steam shovel to a depth of about 18 feet, and the bottom portion of the excavation was removed with derrick and buckets.

The most difficult portion of the work is on those contracts lying along and upon the railway property. For a distance of over a mile the excavation is upwards of 30 feet deep and for a considerable distance more than 40 feet. The railway company refused to allow the sewer to be constructed by the use of ordinary methods of sheeting and bracing. As a result, the city was forced to make supplemental contracts for the use of heavy sheet piling driven along the margins of the trench before the excavation was begun. Wakefield sheet piling, made up of three thicknesses of 3 inch by 12 inch planking, bolted together in lengths of 28 feet, is driven by steam hammer with the aid of a water jet. This adds greatly to the cost of the sewer, as it was necessary to pay the contractor at the rate of $45 per 1000 feet B. M. for this sheeting. The additional precautions, required on account of the main passenger tracks of a railway only 15 feet distant, make such special precautions necessary throughout the entire work, and it would have been better, as already mentioned, if an independent right of way had been purchased, farther away from the railway track.

The work of Messrs. J. Connelly & Son under these trying conditions has been very commendable, but the progress has necessarily been slow and tedious, the monthly progress being only from 75 to 125 feet. This slow progress is also accounted for largely by the enormous quantities of earth which must be handled by the cableway, and the further fact that all the cross bracing timbers must be placed by the use of the cable, and that all of the bricks required for

the invert work must be lowered in the cable buckets. The rate of progress is therefore practically limited by the capacity of the cable machinery. The rate at which the arches can be constructed is much greater, varying from 12 feet to 36 feet daily, depending upon how much invert and side wall can be prepared. Fig. 16 is a view of this work, taken from about half way down the trench.

On account of the slow progress made by the open cut method, and to the fear of damage to some brick buildings which stand within 2 or 3 feet of the trench on the north side, the contractors negotiated with Dennon & Son to sub-let about 1000 feet of the work and to construct it in tunnel.

With the city's approval an agreement was entered into under which a full 4-ring brick sewer is to be substituted for the concrete and steel section, the work to be done under air pressure. Without going into details, I could not give my approval to this change in plan, as I feared it was an unsafe section and one which would involve the city in greater cost for the sewer, but the sub-contractors have begun work upon the tunnel, operating from a shaft located about 100 feet east of Doan Street.

On account of the increased cost of building a sewer upon the railway land, a right of way has been acquired for the Clement's contract, extending west from Lewis Street to Bratenahl Road, and it is hoped that this portion of the work can be completed without the use of the expensive sheet piling. The change, however, was not made until about 200 feet of the sheet piling had been driven along the old location, which piling, of course, will have to be abandoned. The work of constructing the sewer, on the revised location on the north side of the railway and across Doan brook valley, is practically completed. The remainder of the contract will probably be nearly finished during the coming season.

The section extending east from Doan Street, which was awarded to Christian Burkhart, was afterward sub-let to Messrs. John Wagner & Son, who are also the contractors for the continuation of the sewer east to Eddy Road. During the past season their forces have been occupied on a section immediately west of Eddy Road, so that the Burkhardt section, although under contract for about two years, has not as yet been actually begun.

Throughout the entire season work has progressed upon the section between Eddy Road and Coit Avenue, about 600 feet of sewer having been completed. It is thus readily seen that it will be from one to two years yet before the contracts will be completed.

The terminal portion of the work in Lake Erie has not as yet

been awarded. Considerable time and study were necessary in order to determine what would be the proper method of carrying the sewage into the lake, as it requires building a sewer a distance of from 3000 to 4000 feet from shore, and making a discharge near the bottom in about 40 feet of water. The recent disasters upon the waterworks tunnel, and the further fact that test wells in the bed of the lake along the proposed route developed large quantities of marsh gas, indicated that it would be too dangerous an undertaking to build the outlet in tunnel. The cost of building a structure to this distance from shore and supporting it upon piling and break-

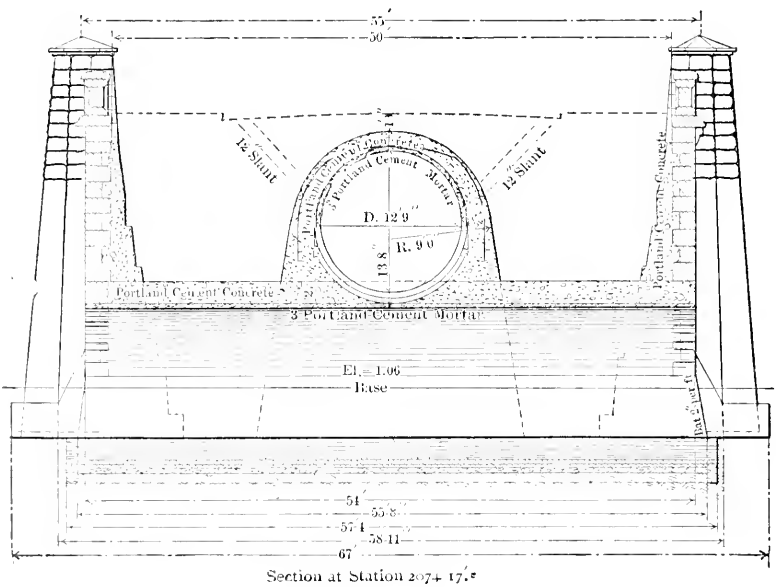

FIG. 17A. DOAN VALLEY CROSSING.

water protection, on estimate, was found to be too great. It has therefore been practically decided to lay submerged pipes in the bottom of the lake.

It is possible to dredge channels in the bed of the lake and to imbed pipes in the bottoms of these trenches. After the sand or clay has been filled over the pipes, they will be free from any danger of disturbance from the lake currents.

The flood water level in the intercepting sewer, just before its discharge into the outlet pipes, will be about 13 feet above base, or about 15 feet above ordinary lake level. It is possible, however, that, at some future time, owing to Government regulation works in the Niagara River, the water level of Lake Erie will raise the level

to base. The hydraulic grade for the outlet pipes is therefore determined by the difference of level of water in the sewer and the lake level at base. It was found on calculation that the desired capacity could be obtained by the use of one 8-foot outlet pipe and one 4-foot pipe. The 4-foot pipe would be sufficient to carry the ordinary sewage flow for some years to come, and the 8-foot pipe would be reserved for flood water discharge. Several smaller pipes could be used in place of one 8-foot pipe, but the cost would be increased and no adequate advantage gained. If it should be deemed desirable to distribute the points of discharge, branches of varying length could be made from the 8-foot pipe at a less cost than would be incurred by the use of several smaller pipes for the whole distance. By the use of one small pipe for sewage, and one large pipe for the maximum flow under storm conditions, velocities of from 10 to 13 feet per second can be obtained in the pipes, which would probably prevent the deposit of sediment or would clear the pipes of any sediment which might accumulate during dry weather conditions.

The selection of the material for these pipes is important. For the 4-foot pipe there is hardly a doubt that cast iron, all things considered, will be most suitable. But for the 8-foot pipe, the cost can be reduced by the use of wooden stave pipe. It would be difficult to prevent a pipe, made entirely of wood, from floating. By making the lower quadrant of cast iron, however, and the upper three quadrants of wooden staves, with the whole pipe properly banded with steel rods, great strength and durability could be obtained, and a considerable saving in cost effected. Such a pipe would sink of its own weight, and the lower part of the pipe, being made of cast iron, would resist the wear caused by the sediment in the flow.

It is the intention to build, at the end of the 13-foot 6-inch intercepting sewer on the margin of the lake, sedimentation and regulation tanks, so that the heavier sediment will be deposited, and thus prevented from entering the outlet pipes, and, also, for the purpose of screening off any floating rubbish. While considerable study has been given to both the matter of the sedimentation tanks and to the outlet pipes, and several different plans have been prepared, detailed plans have not yet been fully determined upon, nor any contracts let.

In the spring of 1903, a contract was awarded to the W. J. Gawne Co. for constructing the section of the main intercepting sewer immediately east of the Cuyahoga River, in Lake Street from Water Street to Muirson Street. The diameters of this sewer are 8 feet and 8 feet 3 inches, and the grade line is about 45 to 50 feet below the street surface. Borings indicated that the tunnel would be in fairly good clay, but was overlaid by beds of water-bearing sand.

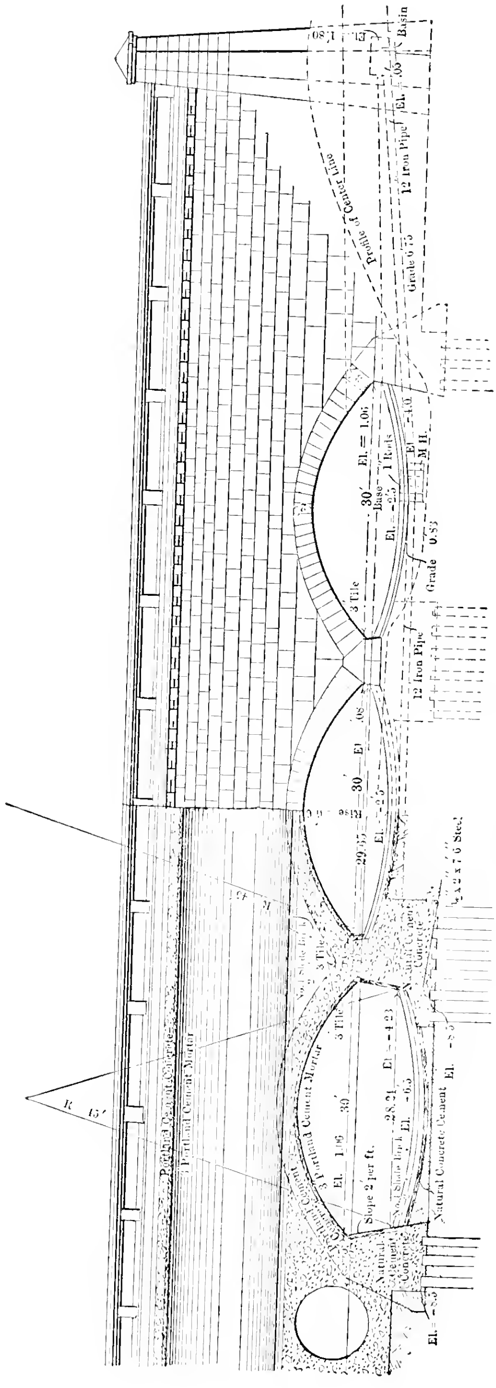

FIG. 17B. DOAN VALLEY CROSSING OF MAIN INTERCEPTOR.

Plans called for building the sewer under compressed air. At each street intersection, shafts were planned, which were later to be used as permanent manholes. According to the plan, the manhole shafts were to be braced with wooden sheeting and timbers, and then lined with 12 inches of brick masonry. Instead of the timber shaft,

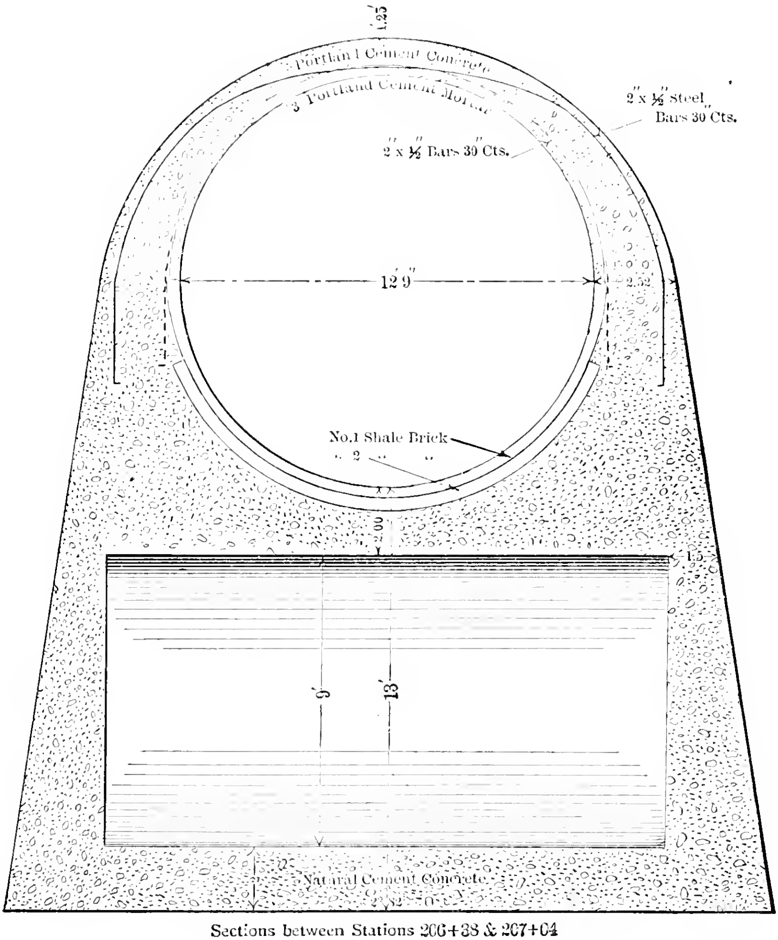

FIG. 17C. DOAN VALLEY CROSSING.

however, the contractor was allowed to use a circular steel cylinder 10 feet in diameter, which was sunk as the excavation progressed, and which was later lined with three courses of brick masonry.

The tunnel was designed circular, with three full rings of shale brick laid in Portland cement mortar. Bids were first received May 29, 1902, and awarded to John Wagner & Son, they being the lowest

bidder at $135,750. Subsequently, however, they claimed that they had made an error in calculating the cost of the manhole shafts, and induced the city to release them from their obligation. On the second letting, July 10, 1902, the work was awarded, as mentioned, to the Gawne Co. for $191,100. The work was begun about October 1, 1902, and completed about September 1, 1903.

Credit is due to the contractors for the vigorous and successful manner in which the work was carried through. They installed boilers, compressors, electric lights, and engine capacity of about double that required by the specifications. They were thus fully insured against the delays which so frequently happen in such work. The working shaft was placed near the east line of Wood Street, about the middle of the contract, and the work was driven in both directions from this shaft until it was completed. All of that part lying between Wood Street and Muirson Street was driven under air pressure of about 10 pounds per square inch, but, although they had the air-lock on hand, it was found not to be necessary for the part west of Wood Street. In each heading, a daily progress of about 16 feet was made, and as high as 18 feet was not at all uncommon.

A small 5-foot tunnel contract was let February 26, 1903, to the Ohio Contracting Company, for a temporary outlet from the main intercepting sewer, extending from Lake Street to Lake Erie, and discharging northerly on Marquette Street. This tunnel connected with the outlet portion of the Marquette main sewer. The purpose of this tunnel is, first, to afford drainage during construction for the portion of the intercepting sewer between Muirson Street and Marquette Street, and, second, to provide a temporary or emergency discharge at any subsequent time from the intercepting sewer. The work was completed during the summer of 1903 at a cost of about $10,000. No special difficulties were encountered, and no special interest pertains to the work.

The Doan valley branch intercepting sewer, as already mentioned, extends up Doan brook valley from the junction with the main interceptor a distance of nearly 4 miles to Cedar Avenue.

The sewer was located in the winter of 1900 and 1901, and bids were received in the summer of 1901, aggregating about $165,000 for the entire work. As the location had been made along the eastern bluff line of Doan valley, and for a large part of the distance in the Rockefeller parkway, objection was made to the location on the ground that the construction of the sewer would disfigure the park. It was the opinion of the Engineering Department that the damage to the park would be insignificant in comparison with the saving of

cost which could be effected by using this location. After an investigation, however, the Mayor decided against the portion of the location north of where Doan brook crosses Doan Street, and ordered a new location higher up on the bluff line to the east. This delayed the construction of the sewer one year, so that the contracts for the second location were not received until 1902, and, on account of the increased depth of the sewer and the increased cost of labor and materials required, the total cost of the Doan valley intercepting sewer was increased over $100,000. The upper section, extending from where Doan brook crosses Doan Street, however, was awarded on the original bid and location to the Clements Bros. Construction Co., but the location was almost entirely changed after the contract was awarded and the work begun. Settlements, according to this new location, have not been made with the contractor.

For the portion of the work down stream from where Doan brook crosses Doan Street, the work was awarded in three sections, the division points being at Superior Street and St. Clair Street. The portion north of St. Clair Street is under contract to the Beers & Doolittle Co. for $22,198.05, but is not yet constructed. The portion between Superior and St. Clair Streets was let to J. Connelly & Son, for about $100,000, and is nearly completed. The section extending from Superior Street up to Doan Street where Doan brook crosses, was let to J. Reaugh & Son, for about $50,000, and is completed with the exception of about 2160 feet in Doan Street extending north from Doan brook. The Doan valley sewer is of No. 4* size at the upper end, increasing to No. 8* where it joins the new interceptor. It is designed to carry a volume of mixed sewage and storm flow equal to 7 times the maximum sewage flow from the territory; and storm overflows connecting with Doan brook are therefore built on all connecting sewers. No especial interest attaches to the work, beyond the fact that a considerable portion of it is deep and a large amount of quicksand and water was encountered. The Reaugh Construction Co. built a large part of their work in tunnel, but the sand at the heading frequently caved in, so that open excavation had to be resorted to. The work will be completed down as far as St. Clair Street early the coming season, and it is the intention to build a temporary pumping plant at St. Clair Street, and pump the ordinary sewage flow westward into the end of the St. Clair Street sewer, and so prevent the discharge of connecting sewers from flowing into and polluting Doan brook.

The following general statements in regard to the intercepting sewer may be made:

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* No. 4 Cleveland egg-shaped sewer is 2.54′ x 3.23′, and the No. 8 sewer, 4.04′ x 5.12′.

The portion of the main sewer along the lake front, which is not under contract as yet, is that portion extending from Gordon Avenue, on the west side, easterly across the Cuyahoga River valley to the intersection of Water and Lake Streets; the portion from Muirson Street to Ansel Avenue and the pipe line system at the outlet into Lake Erie. None of the branches enumerated has been contracted for, with the exception of that in Doan valley, as already described. The aggregate cost of the portion of the intercepting sewer already built and under contract, will be about $2,650,000, and, for the portions of the high level system not as yet under contract, including the branches enumerated, about $2,800,000. In spite of the fact that the Cleveland sewer system has been the result of local growth and requirements, the intercepting sewers, when completed, in connection with the improved water supply, will, I believe, give the city a satisfactory solution of the problem of final disposition of its sewage, and the elimination of pollution from its water supply and water front.

VITAL STATISTICS OF ST. LOUIS SINCE 1840.

By Robert Moore, Member of the Engineers' Club of St. Louis.

[Read before the Club, January 6, 1904.*]

In the history of a city few things are more significant of the conditions of life at any time than is the death rate at that time; and in the fluctuations of the mortality curve, based upon a series of such facts, is found the best index of the success or failure of the city's inhabitants in the primary and universal struggle for existence.

But for our own city no such curve has yet been constructed; and, as the data necessary for its construction are much scattered and comparatively inaccessible, it has seemed to the writer worth while to collect and arrange them and to call attention to a few of the facts which they disclose, some of which are of special interest to the engineer.

AUTHORITIES.

The authorities for the number of deaths given in the tables presented herewith are as follows:

1. For the period from 1841 to 1854, inclusive, the total number of deaths was taken from a document found on pages 311-322 of a "Report on the Diseases of Missouri and Iowa," presented in 1855 to the American Medical Association by a committee of which Dr. Thos. Reyburn was chairman. The document in question is a short report, with tables and diagrams on "The Meteorological Causes of Climatic Diseases in St. Louis," by Dr. George Engleman, first President of the St. Louis Academy of Science and well known for his contributions to botany and local meteorology.

2. For the year 1867, all the data are from the "First Annual Report of the Board of Health of St. Louis," which was organized under a statute approved March 11th of that year, and of which Dr. John T. Hodgen was President.

3. All other data are from the annual and monthly reports of the St. Louis Health Department, organized in 1877 under the charter of the preceding year. For the years prior to 1877, the figures contained in these reports are compilations and are not as much in detail or quite as trustworthy as are those for subsequent years. For the years prior to 1867, details are greatly lacking, all that is given being the total number of deaths for each year and those due to a few special causes.

* Manuscript received June 3, 1904.—Secretary, Ass'n of Eng. Socs.

POPULATION: METHODS OF INTERPOLATION.

These authorities were drawn upon for the number of deaths and for nothing more. But in order to compute the deaths per thousand it is necessary to know, or from known facts to estimate, the population for each year. With, however, the single exception of the year 1866, when a census was taken by the city, there has been an actual enumeration but once in 10 years. It therefore becomes necessary to find the figures for the intervening years by some method of interpolation.

The first way of doing this is by the graphic method. By this method the figures for the census years are plotted as points on a diagram, years being counted on the horizontal axis and population on the vertical axis. The points thus established are then joined by curved lines which shall fit them as nearly as possible. The population for the intercensal years is given by the ordinates of the points where the joining line crosses the lines for those years. This method is based upon the assumption that the increase of population is a continuous flow, and that the values for each year, if plotted on a diagram, will lie in a curve, with no violent breaks. When used for interpolation, the degree of accuracy attained by this method depends upon the care used in fitting a curve to the fixed points and upon the scale of the drawing.

A second method is by computation, and may be called the compound interest method. This method assumes that the annual increase between two enumerations is by a percentage of the last value, and that for the given interval this percentage is constant from year to year. This makes the interpolation between two enumerations a problem in compound interest, and the values found, if plotted, will lie on a curved and not on a straight line.

A third method is the so-called "arithmetical method," adopted by the United States Census Bureau. It is based upon the assumption that the increment for each year between two successive enumerations is not a constant percentage, but a constant quantity, to wit: one-tenth of the decennial increase. This method makes the work of interpolation between two enumerations a matter of simple addition of a constant increment, and the values thus found, if plotted, will lie in a straight and not in a curved line. The diagram for several census periods would, therefore, be a polygon with angles at each census year. This means that at each census year, and at no others, the yearly increment of population changes, a proposition for which there is no foundation either in reason or in fact.

The same objection holds in regard to the compound interest method, in which the percentage of annual increase changes at the census years and at no others. In fact, however, the time of taking the census and the rate of increase of population have no necessary relation of any kind to each other. In the normal growth of a city the percentage of increase, as well as the actual increment, changes slightly from year to year with no great or abrupt changes at any time.

But this assumption is the basis of the graphic method, which is therefore the method most in accordance with the underlying

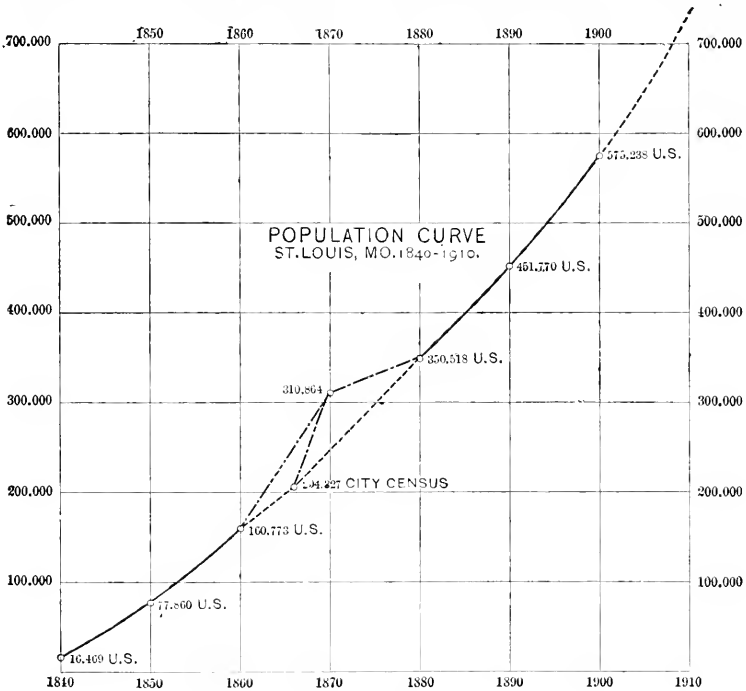

DIAGRAM I.

fact of a continuous and slowly changing process. It is true that the values thus given are never quite exact, but may always be somewhat in error. But the percentage of such error is probably never greater than that of an enumeration, which in a large city can never be exactly correct, and the apparent exactness given by other methods is delusive. On the other hand, the graphic method, as we shall presently see, has the signal advantage of making the detection of any large errors easy and certain.

In this investigation, therefore, the writer has adopted the graphic method and in computing death rates has, for the intercen-

sal years, used population values which were scaled from a carefully drawn diagram. Such a diagram for the population of St. Louis from 1840 to the present time is submitted herewith (Diagram 1).

In looking at this diagram a conspicuous feature is the fact that the point representing the census figures of 1870 does not fit into the series, but that its inclusion in the curve makes a bad and very improbable break. This is particularly true if the figures of the census of 1866, taken by the city, be also included. On the other hand, if the census of 1870 be excluded the curve becomes fairly smooth. The only exception is a slight downward bend caused by the census of 1866. If, however, we bear in mind the depressing effects of the Civil War and the cholera epidemic of 1866, this drop in the curve is fully explained. In like manner the steeper slope between 1866 and 1880 is accounted for by the renewed prosperity following the war and also by the extension of the city limits in 1870 and again in 1876.

This lack of congruity in the census of 1870, as shown by the diagram, brings out clearly the fact that this census is unreliable and worthless; and from direct testimony there is little room for doubt that it was padded and fraudulent. So clear was this that in 1880 the Health Department, which before then had been seriously misled, was forced to discard the census of 1870 and to reduce the population figures for this year by more than 60,000.

During the 20 years from 1880 to 1900 there were no changes in the city limits, the city's growth was normal and there were no efforts to inflate the census figures. As a consequence the curve for this period is smooth and regular, and beyond doubt expresses very closely the facts of the city's growth during these years. And in the absence of an actual enumeration, the prolongation of this curve, shown in the diagram, is the best available index to the present population.

RESULTS.

Applying the figures for the population thus obtained to those giving the number of deaths, already referred to, the deaths per 1000 have been computed for each year from 1841 to 1903, inclusive, a period of 63 years. The results are set forth in Tables 1 and 2 and the diagrams which accompany them.

It may be remarked in passing that the record thus shown is perhaps as long as can be shown for any American city. Even for London, exact records do not go farther back than 1838. The first

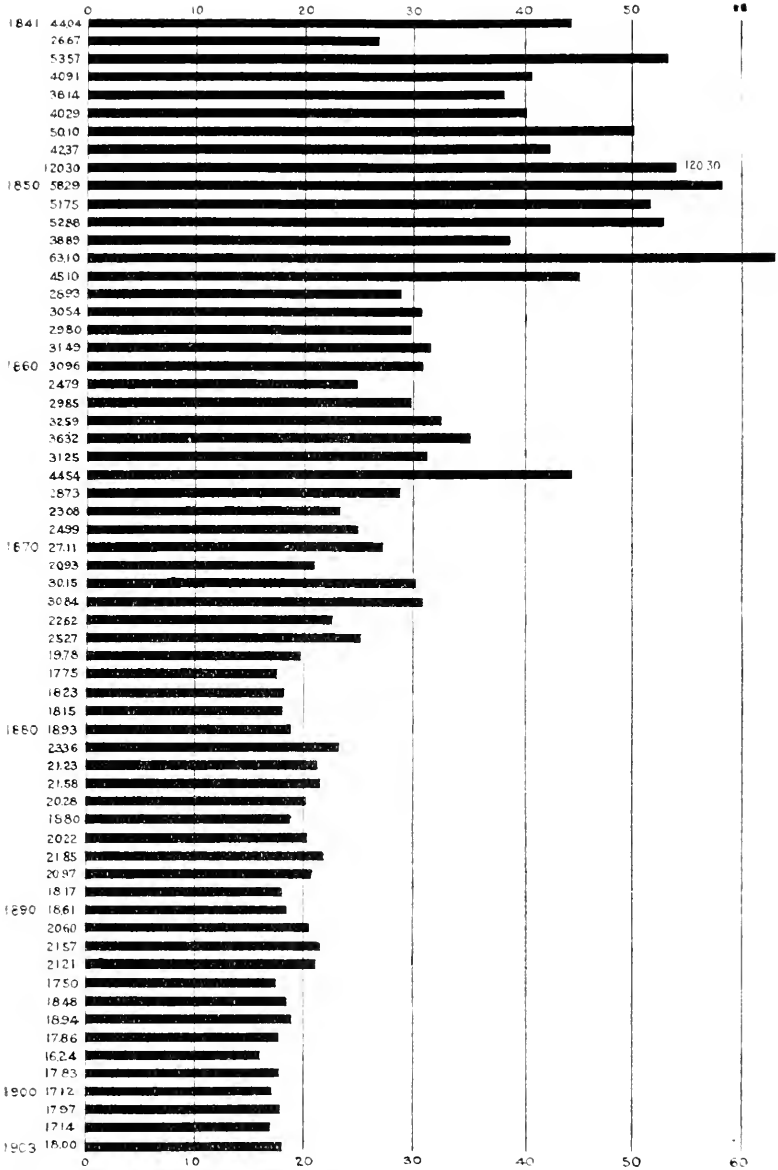

DIAGRAM 2. DEATH RATES PER 1000 OF POPULATION, 1840-1903.

of the series of annual reports of the Registrar General of England was published in 1839.

Referring to Diagram 2, which shows the death rates from all causes, the first thing to strike the eye is the very high death rate which prevailed during the first 3 decades, from 1841 to 1870,

inclusive. During the first 2 decades the lowest rate reached was 26.07 per 1000 for the single year 1842, the rest ranging from 28.93, in 1856, up to maximum of 120.3, in 1849. In the third decade, 1861-70, there were but 3 years below 25, the other 7 years ranging from 27.11 up to 44.54.*

The violent fluctuations from year to year are also very noticeable. We find, for example, differences between succeeding years of 12.67, 13.81, 14.99, 21.20, 26.90, and in one case as much as 77.93

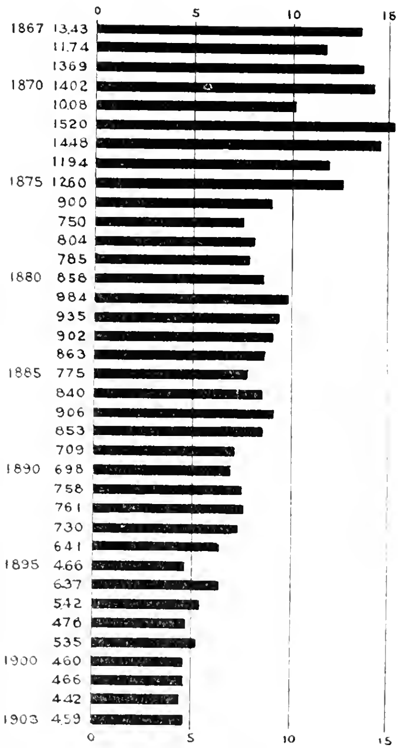

DIAGRAM 3. DEATH RATES UNDER 5 YEARS, 1867-1903.

per 1000. All of these wide fluctuations, with the possible exception of 26.90 between 1842 and 1843, were due to epidemics of cholera. There were also epidemics of cholera during the previous decade, 1831-40, though the exact figures cannot be given; so that for 40 years cholera was almost as great a scourge in St.

* There is little doubt that the mortality from cholera during the first two decades was materially increased by the deaths of immigrants who had come to the city on their way to points further west; but as the number of such deaths cannot now be told there is nothing to do but to leave the figures as they stand.

Louis as in Calcutta. In this, however, St. Louis was not alone. The cholera diagram for London during this period has a striking resemblance to that of St. Louis. There, as here, there was a sharp epidemic in 1849, and again in 1854 and in 1866; and it is more than probable that the diagrams for other American cities would show a like resemblance. Prior to 1870 cholera was a source of terror to the whole civilized world, and when it appeared in St. Louis it could always be traced back to Europe; but though not

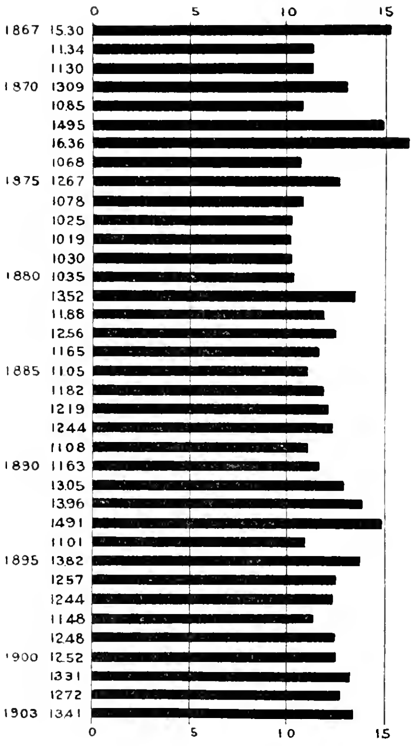

DIAGRAM 4. DEATH RATES, 5 YEARS AND OVER, PER 1000 OF POPULATION, 1867-1903.

indigenous, it never failed, during these first 3 decades at least, to find here a most prolific soil.

During the last 3 decades from 1871 to 1900, inclusive, the improvement in the health conditions of St. Louis is very marked. Both the maximum and the minimum mortality rates are much lower than during the preceding period. The 3 worst years were 1872, 1873 and 1875, when the death rates were 30.15, 30.84 and 25.27 per 1000 respectively. These high rates were mainly due to

smallpox, from which cause there were, in 1872, nearly 1600 deaths, or 5.96 per 1000, an intensity which reminds us of the days before Dr. Jenner. But here, again, we find like conditions to have prevailed elsewhere. In 1871 and 1872 smallpox was epidemic in London. In 1872 and 1873 it was epidemic also in Boston, though it was not as severe as in St. Louis. In addition to smallpox there was, in 1875, an epidemic of scarlet fever, which caused 508 deaths, or 1.71 per 1000, the largest rate on record from this cause in the history of the city.

Since 1875 the highest rate reached was 23.36, in the year 1881; that is to say, the maximum rate for the last 28 years is barely more than the minimum rate for the 30 years 1841-1870. In 1898 was the lowest rate for the whole period of 63 years, to wit, 16.24 per 1000.

The rates for each of the 6 complete decades and for the 3 years, 1901-03, of the seventh decade are shown by the following table. In this table are also given the mean duration of life corresponding to each rate * and the change therein for each period.

Period.	Death Rate per 1000.	Mean Duration of Life.	Change from Last Period.
1841-1850	55.18	18.12	
1851-1860	38.62	25.89	7.77
1861-1870	30.13	33.19	7.30
1871-1880	21.94	45.58	12.37
1881-1890	20.43	48.94	3.36
1891-1900	18.64	53.65	4.71
1901-1903	17.71	56.48	2.83

From this it appears that the death rate, which for the first decade was 55.18, has declined until for the last 3 years it has been 17.71 per 1000, or less than one-third of what it was at the outset; or, to state the same facts in other words, the expectation of life of the child born in the years 1841-1850 was only 18.12 years; for the child born in 1902-03 it was 56.48 years, or over 3 times as long. The total increase in the mean duration of life was 38.36 years, a record of gain which it is difficult to equal.

COMPARISON WITH OTHER CITIES.

To show how the present death rate in St. Louis compares with those of other American cities, a table giving the population and death rate for 14 such cities, compiled from the census of 1890, is subjoined.

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* The rates for the several periods here given are the quotients obtained by dividing the mean yearly deaths for each period by the mean population for the same period.

City.	Population.	Death Rate.
New York	3,437,202	20.4
Chicago	1,698,575	16.2
Philadelphia	1,293,697	21.2
Boston	560,892	20.1
Baltimore	508,957	21.0
Cleveland	381,768	17.1
Buffalo	352,387	14.8
San Francisco	342,782	20.5
Cincinnati	325,902	19.1
Pittsburg	321,616	20.1
New Orleans	284,104	28.9
Detroit	285,704	17.1
Milwaukee	285,315	15.7
Washington	278,718	31.1

The average rate for 1900 in these 14 cities was 19.63, or 1.93 greater than the St. Louis rate for the years 1901-03. The only cities showing a less rate than ours are Chicago, Cleveland, Buffalo, Detroit and Milwaukee, in which the average rate for 1900 was 16.22, or 1.48 less than our own. In regard to these cities, however, it is worthy of note that the percentage of negroes, among whom the death rate is always much greater than among the whites, is very small, namely 1.12 per cent. as compared with 6.2 per cent. in St. Louis. Besides which a close scrutiny of the facts might show that the figures of population in these cities are incorrect; for, as we have already seen in our own history for 1870, even a census report may be heavily padded, of which there is no surer sign than an exceptionally low death rate. For example, when we find, as we do in the census figures for 1900, 3 cities, one of them in Missouri, in which the death rates indicate a mean duration of life of 103, 105 and 110 years respectively, we can be very sure that the figures of population need to be revised.

CONTROL OF EPIDEMICS.

Coming now to the causes of this very great lowering of the death rate and the consequent increase in the mean duration of life, we find, as a general statement, that it is due to a better knowledge of the causes and cure of disease and the methods of its prevention, and to a better observance of the laws of health which this knowledge has disclosed.

This is well illustrated in the case of cholera, which, as we have seen, was for 30 years in St. Louis a frightful scourge. But at that time its cause and the methods of its propagation were unknown. When, therefore, the pestilence appeared the people knew not what to do. In their bewilderment the city authorities

appointed days of fasting and prayer and burned tar barrels in the streets, meantime doing nothing really effective to prevent the disease from spreading. Were it to appear now, something extremely

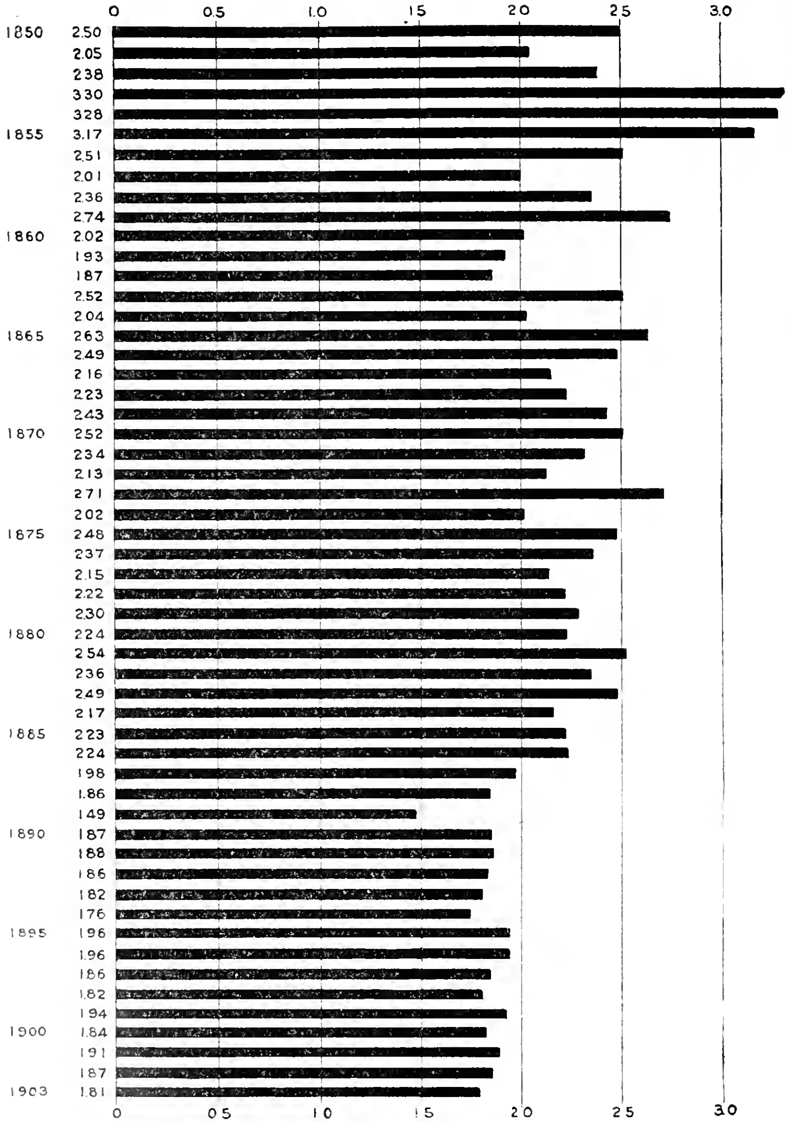


Diagram 5. Consumption Death Rates per 1000 of Population, 1850-1903.

improbable, the cases would be promptly isolated, the excreta disinfected, and a general purification of drinking water by filtration and by boiling inaugurated; for by such measures, as we now

know, the propagation of the disease is made impossible. In fact cholera is not likely, hereafter, ever to become epidemic in any large European or American city. Much the same may be said of smallpox, of yellow fever and of the plague, for each of which the means of prevention are now well known.

REDUCTION OF THE INFANT DEATH RATE.

Next in importance to the control of epidemics as a factor in increasing the mean duration of life has been the very marked

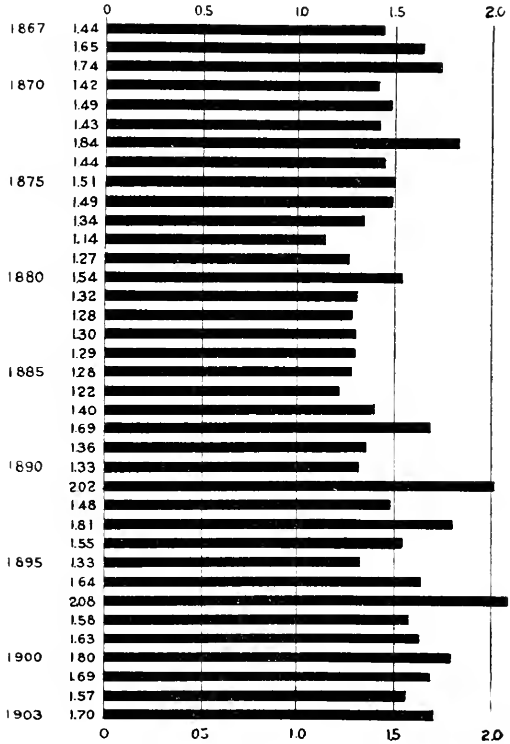


DIAGRAM 6. PNEUMONIA DEATH RATES PER 1000 OF POPULATION, 1867-1903.

decrease in the deaths of children under 5 years, which, for the 37 years from 1867 to 1903, inclusive, is shown in Table 2 and Diagram 3, herewith submitted. As a rule, with almost no exceptions, this class embraces a larger number of individuals than is found in any other class embracing an equal number of years. Potentially, therefore, no class of the population is more important. In the last two censuses the proportions of the population embraced in this class in the whole United States have been, for 1890, 12.2

per cent. and for 1900, 12.1 per cent. In St. Louis they have been, for 1890, 9.96 per cent. and for 1900, 9.91 per cent. For round numbers, therefore, we may say that the proportion of the popula-

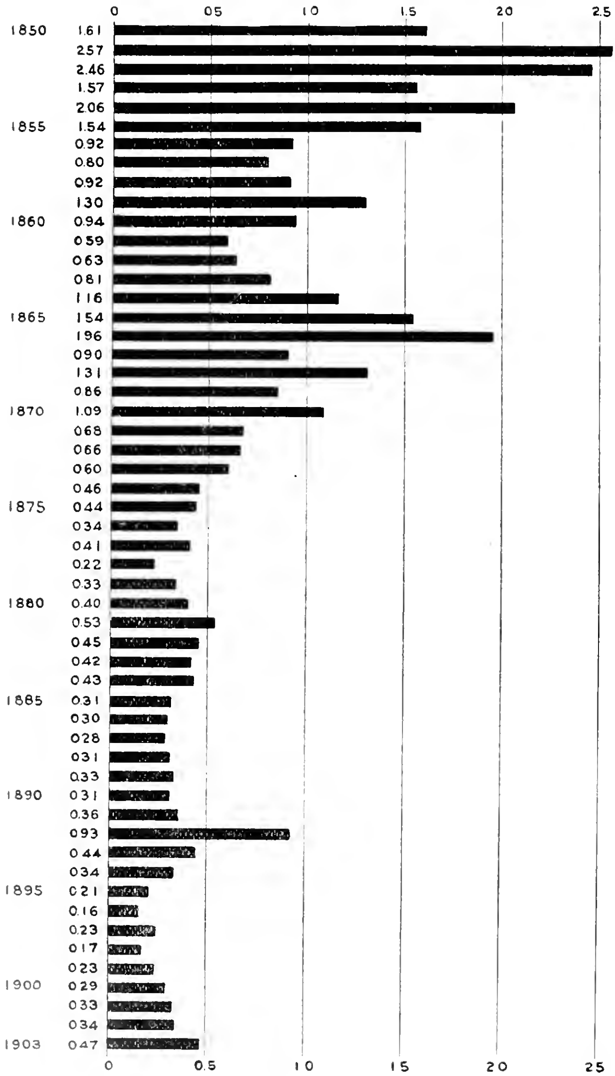


Diagram 7. Typhoid Fever Death Rates per 1000 of Population, 1850-1903.

tion under 5 years of age in St. Louis is 10 per cent. Being also the feeblest element of the population they are the most easily affected by morbific influences, a liability which inevitably results in a higher death rate than is found in any other class.

Table 2 shows that during the 4 years from 1867-1870 the deaths of children from 1 to 4 years of age amounted to 13.25 per 1000 of the total population, which, bearing in mind that this class numbers one-tenth only of the whole, means a rate of 132.5 per 1000 of those belonging to this class. For the years 1872 and 1873 the rates per 1000 of those belonging to this class were 152 and 148.8 respectively, or more than 1 in every 7. Since 1873 this rate has rapidly decreased until for the 3 years

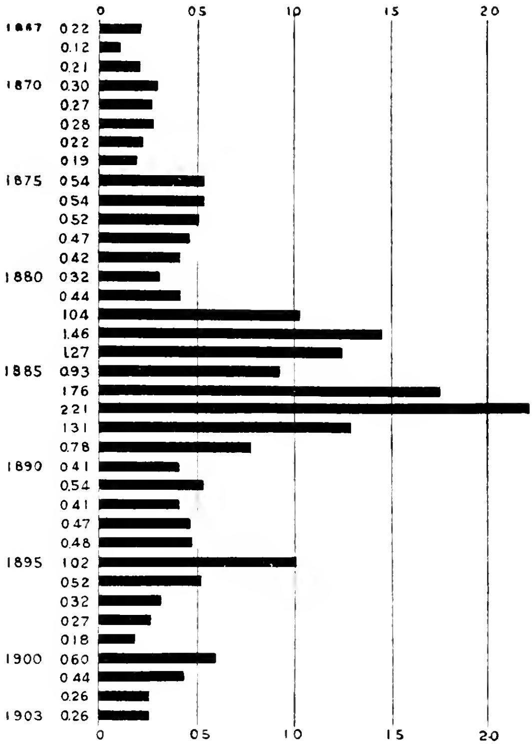


DIAGRAM 8. DIPHTHERIA DEATH RATES PER 1000 OF POPULATION, 1867-1903.

1901-03 it was 45.6 per 1000, still a very high rate, but less than one-third of what it was only 30 years before.

Meantime the changes in the death rate of the remaining nine-tenths of the population, embracing all those of 5 years of age and over, as shown in Diagram 4, have been comparatively small. This fact is brought out in the following table, which gives the deaths and the death rates in St. Louis from 1867 to 1903, inclusive, first for children under 5 years, and, second, for all persons 5 years of age and over.

Period.	Sum of Population per Year.	Children under Five Years of Age. Total Deaths.	Rate per 1000 of the Class.	All Persons Five Years of Age and Over. Total Deaths.	Rate per 1000 of the Class.
1867-1870	921,400	12,209	132.48	11,709	14.12
1871-1880	3,032,918	31,319	102.32	35,071	12.85
1881-1890	4,045,670	34,059	84.19	48,601	13.35
1891-1900	5,173,438	30,703	59.35	65,719	14.11
1901-1903	1,813,000	8,261	45.01	23,838	14.61
1867-1903	14,986,426	116,551	77.77	184,938	13.71

From this table it will be seen that during the decade 1871-80 the rate per 1000 of those 5 years of age and over dropped from 14.12 to 12.85, or 1.27 per 1000. Since then, however, it has been slowly increasing, and for the 3 years 1901-03 was 14.61, which is 1.76 per 1000 greater than in 1871-80 and 0.49 greater than in 1867-70. So that since 1866, the date of the last great epidemic of cholera, the decrease in the total death rate is wholly due to the very marked decrease in the deaths of children during the first 4 years of life.

This revolutionary reduction in the infantile death rate—one of the most important events in the city's history—has been brought about, speaking broadly, by greater knowledge of the causes of disease, and, as a result of such knowledge, by better food and more skillful care. Part of it has been brought about by the better control of diphtheria since the introduction of the seropathic treatment. (See Diagram 8.)

CONSUMPTION AND PNEUMONIA.

Next after the mortality among children under 5 years as a factor in the general death rate is consumption, the course of which from 1850 to 1903 is shown in Tables 1 and 2 and on Diagram 5. Here also we note a decline from 2.56 per 1000 for the 11 years 1850-60 to 1.81 in 1903, and 1.89 for the 13 years 1891-1903. This decline is part of a general movement in all enlightened countries, which in Massachusetts has brought the death rate from this cause down from 3.99 per 1000 in the decade 1851-60 to 1.59 in 1902, a reduction of over 60 per cent. It is noteworthy that in St. Louis the most marked reduction has taken place since 1886, soon after Dr. Koch's announcement of the true cause of the disease. That by sanatoriums for the open-air treatment and by the general diffusion of knowledge as to the means of prevention the mortality from this cause can be still further lowered there can be no doubt.

Following closely consumption as a cause of death is pneumonia, the course of which in St. Louis from 1867 to 1903, inclusive, is shown in Table 2 and Diagram 6. Here, however, we find that for

the last 13 years the deaths from this cause have been increasing, so that it is now almost as serious a foe to life as consumption. In fact there have been 2 years, 1891 and 1897, when the deaths from pneumonia exceeded those from consumption. The same conditions substantially are found in Massachusetts, where, in 1900, pneumonia slightly exceeded consumption as a cause of death. Nor is the outlook for gaining the mastery over it at present very promising.

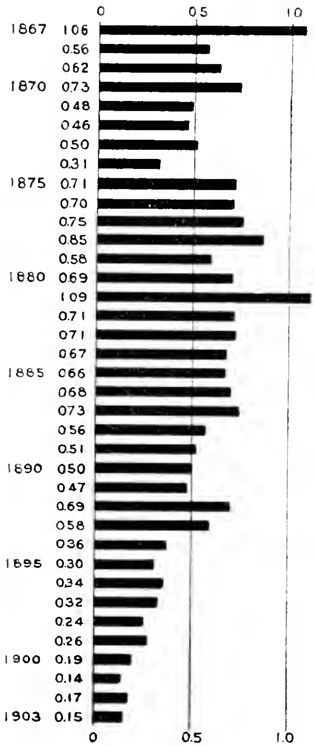


DIAGRAM 9. MALARIA DEATH RATES PER 1000 OF POPULATION, 1867-1903.

TYPHOID FEVER.

In the list of preventable diseases that of greatest interest to the engineer is typhoid fever, the history of which in St. Louis for 54 years, from 1850 to 1903, is given in Tables 1 and 2 and is shown graphically by Diagram 7.

In studying this diagram the first thing to strike the eye is the fact that taking it as a whole there has been a very great decline. From a rate of 1.42 per 1000 in the 11 years 1850-60 there is in the decade 1891-1900 a drop to a rate of 0.33, which is less than one-fourth of the former rate. A second noticeable feature is the wide

TABLE I.

POPULATION, DEATHS AND DEATH RATES, 1841 TO 1866.

Year	Population.	Deaths. All Causes.		Cholera.		Total Except Cholera.		Consumption.		Typhoid.		Smallpox	
		Number.	Rate per 1,000.	Deaths.	Rate per 1,000.	Deaths.	Rate per 1,000.	Deaths.	Rate per 1,000.	Deaths.	Rate per 1,000.	Deaths.	Rate per 1,000.
1840	16,469												
1841	21,800	960	44.04										
1842	27,000	720	26.67										
1843	32,800	1,160	53.57										
1844	38,600	1,579	40.91										
1845	44,600	1,701	38.14										
1846	51,000	2,055	40.29										
1847	57,200	2,866	50.10										
1848	63,800	2,703	42.37										
1849	70,600	8,495	120.30	4,317	61.12	4,178	59.18						
1850	77,860	4,539	58.29	883	11.33	3,656	46.96	195	2.50	125	1.61	7	0.09
1851	84,800	4,388	51.75	845	9.97	3,543	41.78	174	2.05	218	2.57	7	0.08
1852	92,300	4,881	52.88	802	8.69	4,079	44.19	220	2.38	227	2.46	39	0.42
1853	100,000	3,889	38.89	10	0.10	3,879	38.79	330	3.30	157	1.57	22	0.22
1854	107,800	6,802	63.10	1,534	14.22	5,268	48.88	353	3.28	222	2.06	4	0.04
1855	116,000	5,231	45.10	534	4.61	4,697	40.49	368	3.17	179	1.54	28	0.24
1856	124,500	3,602	28.93	5	0.05	3,597	28.88	323	2.51	114	0.92	10	0.08
1857	133,100	4,065	30.54	7	0.05	4,058	30.49	268	2.01	107	0.80	159	1.19
1858	142,000	4,231	29.80	22	0.17	4,209	29.63	335	2.36	131	0.92	15	0.11
1859	151,300	4,765	31.49	13	0.08	4,752	31.41	414	2 74	197	1.30	2	0.01
1860	160,773	4,978	30.96	1	0.00	4,977	30.96	324	2.02	151	0.94	0	0.00
1861	168,200	4,170	24.79	1	0.00	4,169	24.79	324	1.93	100	0.59	2	0.01
1862	175,400	5,236	29.85	7	0.04	5,229	29.82	328	1.87	110	0.63	46	0.26
1863	182,600	5,951	32.59	7	0.04	5,944	32.55	461	2.52	147	0.81	109	0.59
1864	189,800	6,893	36.32	2	0.01	6,891	36.31	388	2.04	220	1.16	63	0.33
1865	197,000	6,157	31.25	4	0.02	6,153	31.23	518	2.63	304	1.54	114	0.58
1866	204,327	9,099	44.54	3,527	17.27	5,572	27.27	508	2.49	401	1.96	27	0.13

TABLE 2.

POPULATION, DEATHS, AND DEATH RATES

1867 to 1903, inclusive.

Year	Population	All Causes Total Deaths: Deaths	Rate per 1,000	Cholera: Deaths	Rate per 1,000	Smallpox: Cases	Deaths	Rate per 1,000	Total Deaths Excluding Two Last: No	Rate per 1,000	Under 5 years: Deaths	Rate per 1,000	5 years and over: Deaths	Rate per 1,000	Scarlet ina: Deaths	Rate per 1,000	Diphtheria: Deaths	Rate per 1,000	Croup: Deaths	Rate per 1,000	Typhoid Fever: Deaths	Rate per 1,000	Diarrheal under 5 years: Deaths	Rate per 1,000	Diarrheal 5 years and over: Deaths	Rate per 1,000	Diarrhea Total: Deaths	Rate per 1,000	Malaria: Deaths	Rate per 1,000	Consumption: Deaths	Rate per 1,000	Pneumonia: Deaths	Rate per 1,000	Still Births not Included in Total	Births Reported	Year
1867	214,800	6,171	28.73	684	3.19	80	18	0.08	5,469	25.46	2,953	13.43	3,218	15.30	27	0.13	48	0.22	58	0.27	194	0.90	173	0.81	823	3.83	996	4.64	227	1.06	464	2.16	309	1.44	371		1867
1868	225,100	5,193	23.08	1		10	1		5,191	23.06	2,582	11.74	2,611	11.34	28	0.12	35	0.12	44	0.20	294	1.31	409	1.82	511	2.27	920	4.09	127	0.56	503	2.23	371	1.65	411		1868
1869	235,500	5,884	24.99	2		502	240	1.02	5,642	23.96	3,225	13.69	2,659	11.30	55	0.23	49	0.21	51	0.22	202	0.86	469	1.99	407	1.73	876	3.72	147	0.62	571	2.43	410	1.74	421		1869
1870	246,000	6,670	27.11	3			375	1.52	6,292	25.58	3,449	14.02	3,221	13.09	263	1.07	75	0.30	92	0.27	260	1.09	371	1.54	528	2.15	899	3.66	180	0.73	620	2.52	350	1.42	477		1870
1871	256,500	5,265	20.93	1			9	0.04	5,255	20.49	2,585	10.08	2,680	10.85	68	0.27	68	0.27	79	0.31	174	0.68	221	0.86	316	1.23	537	2.09	124	0.48	599	2.34	381	1.49	363		1871
1872	266,000	8,047	30.15	5	0.02	3,789	1,501	5.96	6,451	24.17	4,058	15.20	3,989	14.95	47	0.18	76	0.28	66	0.25	176	0.66	456	1.71	544	2.04	1,000	3.75	124	0.46	568	2.13	352	1.33	630		1872
1873	277,300	8,551	30.84	131	0.47		837	3.02	7,583	27.35	4,014	14.48	4,537	16.36	22	0.08	61	0.22	78	0.28	167	0.60	496	1.79	691	2.49	1,187	4.28	140	0.50	751	2.71	510	1.84	514		1873
1874	287,600	6,506	22.62				447	1.55	6,059	21.07	3,433	11.94	3,073	10.68	87	0.30	56	0.19	53	0.18	131	0.46	460	1.60	295	1.03	755	2.63	88	0.31	581	2.02	413	1.44	510		1874
1875	298,000	7,532	25.27				603	2.02	6,929	23.25	3,755	12.60	3,777	12.67	508	1.71	160	0.54	72	0.24	131	0.44	378	1.27	315	1.06	693	2.33	212	0.71	740	2.48	450	1.51	421		1875
1876	308,200	6,010	19.78				90	0.29	5,920	19.24	2,840	9.00	3,170	10.78	124	0.40	167	0.54	157	0.51	103	0.34	314	1.02	248	0.80	562	1.82	219	0.70	721	2.37	460	1.49	401		1876
1877	318,800	5,660	17.75			13	1		5,659	17.75	2,391	7.50	3,269	10.25	40	0.13	165	0.52	69	0.21	130	0.41	197	0.62	234	0.73	431	1.35	240	0.75	686	2.15	427	1.34	797		1877
1878	329,300	6,002	18.23						6,002	18.23	2,635	8.04	3,367	10.19	36	0.11	156	0.47	85	0.26	74	0.22	238	0.72	213	0.65	451	1.37	270	0.85	730	2.22	375	1.14	434	4,051	1878
1879	339,800	6,167	18.15						6,167	18.15	2,666	7.85	3,501	10.30	39	0.11	141	0.42	62	0.18	112	0.33	477	1.40	189	0.56	666	1.96	197	0.58	781	2.30	432	1.27	541	4,741	1879
1880	350,518	6,636	18.93			9			6,636	18.93	2,037	8.58	3,600	10.35	47	0.13	113	0.32	61	0.17	130	0.40	488	1.39	161	0.46	649	1.85	241	0.69	758	2.24	539	1.54	561	7,525	1880
1881	360,000	8,410	23.36				115	0.32	8,295	23.04	3,541	9.84	4,869	13.52	108	0.30	157	0.44	68	0.19	191	0.53	686	1.91	195	0.54	881	2.45	393	1.09	917	2.54	475	1.32	668	8,0[illegible]	1881
1882	369,500	7,845	21.23				41	0.11	7,804	21.12	3,454	9.35	4,391	11.88	346	0.94	385	1.04	103	0.28	166	0.45	525	1.42	179	0.48	704	1.90	264	0.71	876	2.36	474	1.28	705	8,491	1882
1883	379,000	8,177	21.58				233	0.61	7,944	20.96	3,420	9.02	4,757	12.56	349	0.92	553	1.46	134	0.35	158	0.42	531	1.40	136	0.36	667	1.76	270	0.71	944	2.49	493	1.30	709	[illegible]	1883
1884	388,800	7,887	20.28			104	29	0.07	7,858	20.22	3,357	8.63	4,530	11.65	161	0.41	495	1.27	116	0.30	166	0.43	582	1.50	130	0.33	712	1.83	261	0.67	844	2.17	501	1.29	769	[illegible]	1884
1885	398,500	7,400	18.80			3			7,400	18.80	3,000	7.75	4,400	11.05	164	0.41	372	0.93	109	0.27	125	0.31	441	1.11	91	0.23	532	1.34	263	0.66	888	2.23	511	1.28	725	[illegible]	1885
1886	408,800	8,268	20.22						8,268	20.22	3,434	8.40	4,834	11.82	149	0.36	719	1.76	160	0.39	124	0.30	334	0.82	97	0.24	431	1.06	279	0.68	915	2.24	507	1.22	765	10,2[illegible]	1886
1887	419,000	9,155	21.85			17	1		9,154	21.85	3,79[illegible]	[illegible]	5,360	12.19	48	0.11	927	2.21	185	0.44	116	0.28	324	0.77	153	0.37	477	1.14	304	0.73	829	1.98	586	1.40	740	10,[illegible]	1887
1888	429,800	9,015	20.97			90	10	0.02	9,005	20.95	3,659	8.53	5,356	12.44	30	0.07	564	1.31	167	0.39	133	0.31	488	1.13	144	0.34	632	1.47	242	0.56	800	1.86	728	1.69	720	11,3[illegible]5	1888
1889	440,500	8,004	18.17						8,004	18.17	3,194	7.09	4,810	11.08	114	0.26	345	0.78	94	0.21	146	0.33	357	0.81	79	0.18	436	0.99	223	0.51	655	1.49	598	1.31	835	11,[illegible]	1889
1890	451,770	8,409	18.61			52	5	0.01	8,404	18.60	3,115	[illegible]	5,294	11.63	87	0.19	186	0.41	58	0.13	140	0.31	435	0.96	104	0.23	539	1.19	226	0.50	843	1.87	601	1.33	7[illegible]4	11,5[illegible]4	1890
1891	462,600	9,530	20.60			26	5	0.01	9,525	20.59	3,493	7.58	6,037	13.05	96	0.21	250	0.54	90	0.19	165	0.36	429	0.93	118	[illegible]	547	1.18	216	0.47	869	1.88	932	2.02	828	11,[illegible]	1891
1892	474,000	10,225	21.57						10,225	21.57	3,607	7.61	6,618	13.96	150	0.32	195	0.41	91	0.19	441	0.93	444	0.93	11[illegible]	0.24	559	1.17	326	0.69	882	1.86	705	1.48	837	12,3[illegible]	1892
1893	485,800	10,303	21.21			3	1		10,302	21.21	3,548	7.30	6,755	14.01	79	0.16	227	0.47	144	0.30	215	0.44	570	1.17	111	0.24	681	1.40	284	0.58	984	1.82	879	1.81	[illegible]	12,[illegible]	1893
1894	497,800	8,710	17.50			220	49	0.10	8,661	17.40	3,102	6.41	5,518	11.01	20	0.06	240	0.48	139	0.28	171	0.34	538	1.08	98	0.20	636	1.28	179	0.36	875	1.76	772	1.55	[illegible]	12,233	1894
1895	510,000	9,425	18.48			114	24	0.05	9,401	18.43	2,375	4.66	7,050	13.82	20	0.04	522	1.02	171	0.34	107	0.21	552	1.08	101	0.20	653	1.28	155	0.30	1,000	1.96	677	1.33	784	11,828	1895
1896	522,500	9,897	18.94			1			9,897	18.94	3,326	6.37	6,571	12.57	8	0.01	273	0.52	104	0.20	100	0.16	664	1.27	111	0.21	775	1.48	177	0.34	1,020	1.96	854	1.64	772	11,291	1896
1897	535,000	9,554	17.86			10	3	0.006	9,551	17.85	2,901	5.42	6,653	12.44	19	0.04	170	0.32	70	0.13	124	0.23	499	0.93	67	0.13	566	1.06	173	0.32	997	1.86	1,115	2.08	776	11,[illegible]	1897
1898	548,500	8,908	16.24			2	0		8,908	16.24	2,608	4.76	6,300	11.48	28	0.05	152	0.27	51	0.09	95	0.17	413	0.75	53	0.10	466	0.85	134	0.24	1,001	1.82	867	1.58	714	10,815	1898
1899	562,000	10,023	17.83			115	5	0.009	10,018	17.82	3,005	5.35	7,018	12.48	38	0.07	102	0.18	49	0.09	131	0.23	451	0.80	64	0.11	515	1.02	148	0.26	1,001	1.94	914	1.63	778	[illegible]	1899
1900	575,238	9,847	17.12			134	2	0.003	9,845	17.12	2,648	4.60	7,199	12.52	57	0.10	344	0.60	65	0.11	168	0.29	402	0.70	67	0.12	469	0.82	112	0.19	[illegible]	[illegible]	1,034	[illegible]	724	[illegible]	1900
1901	590,000	10,601	17.97			879	9	0.015	10,592	17.95	2,748	4.66	7,853	13.31	69	0.12	259	0.44	48	0.08	198	0.33	383	0.65	70	0.12	453	0.76	86	0.14	1,128	1.91	[illegible]	[illegible]	[illegible]	[illegible]	1901
1902	604,000	10,353	17.14			1,548	17	0.03	10,336	17.11	2,671	4.42	7,682	12.72	132	0.22	160	0.26	31	0.05	208	0.34	366	0.61	76	0.13	442	0.74	102	0.17	1,131	1.87	945	1.57	821	11,[illegible]	1902
1903	619,000	11,145	18.00				3	0.005	11,142	18.00	2,842	4.59	8,303	13.41	89	0.14	162	0.26	33	0.05	288	0.47	398	0.64	48	0.08	446	0.72	91	0.15	1,112	1.81	1,054	1.70	774	11,8[illegible]	1903

fluctuations which mark the period prior to 1870 as compared with the less frequent and less violent fluctuations of the period subsequent to 1870, suggesting corresponding variations in the intensity of the cause.

As throwing light upon the causes of these fluctuations certain facts in the history of the city water supply and sewerage systems are of special interest. From 1832, the date of the completion of the first waterworks, until 1871 the intake for the public supply was at the foot of Dickson Street, not far from the present center of the city. In 1832, however, and for 20 years later, no public sewers had been built, the north part of the city was but sparsely inhabited, and the water delivered was comparatively free from pollution. But it was very limited in quantity, and for many years a large, if not the greater, part of the drinking supply was taken from wells which were uniformly shallow and easily polluted. In 1852 the first public sewer was built in Biddle Street, its outlet being about 1100 feet below the waterworks. In 1853, and again in 1855, the capacity of the works was greatly increased by the installation of 2 new pumping engines and the completion of 2 new reservoirs, and the general use of the public supply correspondingly increased.

Contemporaneously with this enlargement of the waterworks we note a very marked drop in the typhoid rate, which, with one upward turn in 1858-59, continued till 1861, when it reached 0.59 per 1000 as compared with 2.57 in 1851, a drop of 77 per cent. Meantime the building of sewers discharging into the river north of the waterworks had begun, and the sewage discharged by Rocky Branch and by Gin-Grass Creek, both in this district, was increasing. At the same time the typhoid curve takes an upward turn, which continues without interruption for 5 years, culminating in 1866, with a rate of 1.96 per 1000, or more than 3 times that of 1861.

The fluctuations of the next 4 years are without explanation in the condition of the water supply, so far as it can now be traced. For though the building of new waterworks in a new location was begun in 1866, and some efforts made in the meantime to improve the old supply, there were no changes in the former condition worthy of mention. But in May, 1871, the new works were inaugurated and the old works abandoned. The new intake was at Bissell's Point, which at that time was above the mouths of all the sewers. The new supply was also allowed to remain for 24 hours or more at rest in the new settling basins before its distribution to consumers, something which before then was impossible.

Coincident with this event the typhoid rate, which from 1869

to 1870 was rising, at once began to fall until, in 1878, it had reached a rate of 0.22 per 1000, a drop in 8 years of 78 per cent. After this, the rate, with some fluctuations, increased until in 1892 it rose in a single year from 0.36 to 0.93. Along with this rise from 1878 to 1892 there was a gradual introduction of sewage into the streams entering the river within the city limits above Bissell's Point; notably into the one nearest the intake pumps, namely Harlem Creek, which had become in effect an open sewer. That this was the chief, if not the only, cause of typhoid infection was so clear that the city authorities were induced to place a pump at Harlem Creek, by which the dry weather flow of the stream was delivered into the Ferry Street sewer, the mouth of which is below the Bissell's Point pumps. The immediate drop in the typhoid rate from 0.93 in 1892 to 0.44 in 1893 points clearly to the relation of effect to cause.

The Harlem Creek pump was maintained until the final abandonment, in 1895, of Bissell's Point as the source of supply and the inauguration of the present intake station at the Chain of Rocks, 6¾ miles further up stream, and above all present or prospective sewage originating in the city itself. During 1896, the first complete year after this last removal, the typhoid rate dropped to 0.16 per 1000 (or 16 per 100,000), the lowest recorded rate, and, no doubt, the lowest actual rate in the history of the city.

Since then the rate has increased until in 1903 it was 0.47 per 1000, or nearly 3 times what it was in 1896. The greater part of this increase has taken place since the opening of the Chicago Drainage Canal, January 17, 1903, the largest single increment, 0.13, having been made in 1903. That part of the increase was due to this new contribution of sewage there can be little doubt. But in view of the great potency of sewage at short range, as shown by the examples already cited from our own history, it is probable that we shall hereafter suffer more from the cities closer at hand, such as Peoria, Pekin, Quincy, Hannibal, Alton and St. Charles, than from Chicago.

Be this, however, as it may, it is certain that as the density of population on the watersheds above us increases the pollution of our water supply by sewage will at the same time, and in large measure unavoidably, increase, and with this will come an increase exposure to the infection of typhoid fever. Equally certain is it that complete exemption from this danger, with which alone we should be satisfied, is something that cannot be secured to us by any court, either State or Federal, but must be attained by our own efforts.

WASTE OF LIFE IN FORMER YEARS.

To those now living the progressive increase in the mean duration of life in St. Louis, disclosed by our inquiry, is very gratifying and hopeful. But when we look backward the figures disclose a serious waste of life which, with our present knowledge, might have been avoided. How great was this waste is shown by the following table, in which the actual mortality for the 6 complete decades ending with 1900 is compared with what it would have been for the same population at a rate of 18 per 1000, which is about the present rate.

Period.	Total Actual Deaths.	Total Deaths at Rate of 18 per 1000.	Difference or Lives Wasted.	Per Cent. of Lives Wasted.
1841-1850	26,778	8,735	18,043	65.83
1851-1860	46,832	21,826	25,006	53.41
1861-1870	61,424	36,697	24,727	40.26
1871-1880	66,385	54,593	11,792	17.76
1881-1890	82,660	72,822	9,838	11.90
1891-1900	96,422	93,122	3,300	3.42
Total	380,501	287,795	92,706	24.37

From these figures it appears that in the first decade the percentage of deaths that with better knowledge might have been avoided was nearly 66 per cent., and for the first 30 years was more than 50 per cent. For the whole 60 years the avoidable deaths amounted to 92,706, or 24.37 per cent. of the whole number. That is to say, the lives of this number of persons might have been prolonged, the extent of this prolongation being the difference between the mean duration of life corresponding to the rate of 18 per 1000 and that corresponding to the actual rate of 23.18 per 1000 for the whole period, or 12.42 years per person. This would have meant an addition to the sum of the city's life—its most valuable asset—of more than 1,150,000 years, all of which has in fact been lost.

A LOOK FORWARD.

From this study of what has been accomplished in the past we cannot help turning to the future with the question, How much further in this direction can we expect to go in the years to come?

Without doubt, there is a limit somewhere which we cannot pass. With every care the human frame will not last forever. Death cannot be abolished. And he would be a bold man who would do it if he could. For, as the world is now built, continued progress is dependent upon the constant influx of new lives with fresh vigor and new minds from which there are no past errors to be erased. Death, in fact, is the necessary condition of the world's higher life.

Something, however, can be done to make life longer, and much can be done to make it more vigorous and effective while it lasts. In particular, we may reasonably hope to still further reduce the rate of infant mortality, in which so much has already been accomplished. It is entirely probable that the present rate for this class in St. Louis, 4.5 per 1000 of the total population, may be brought down to 3, a saving of 1.5 per 1000. So, too, we may expect that the rate for consumption, a disease of the young and middle-aged, which is now 1.89, may be reduced to 1 per 1000, a saving of 0.89. Possibly the rate for pneumonia may be brought to the same limit, which would mean a gain of 0.69; and the typhoid rate ought certainly to be reduced to 0.1 per 1000, a further saving of 0.23. Summing these we have a total gain of 3.31 per 1000; which applied to the present rate for the years 1901-03, to wit, 17.71, leaves a resulting rate of 14.40 per 1000.

On the other hand, this saving, which is mostly of those in early life, will be somewhat reduced by an increase due to the diseases and casualties incident to middle and later life. So that a rate of from 14.5 to 15 per 1000, which corresponds to a mean duration of life of from $66\frac{2}{3}$ to 69 years, is all that we can now reasonably hope for.

To attain this, however, will be no small accomplishment. It will involve a widespread knowledge of the conditions of health and universal compliance therewith. It will mean pure air, pure water and wholesome food for the whole people. It will mean that all must be protected and skillfully cared for when stricken.

But as population becomes more dense and the struggle for existence more arduous, this general sanitation will be a work of ever increasing difficulty. To hold our own will be no small task, to advance will be a great one, in which all classes must join and in which the engineer must bear a leading part.

DISCUSSION.

Dr. S. W. Abbott.—The paper of Engineer Moore, upon the "Vital Statistics of St. Louis Since 1840," is a distinct and valuable contribution to American vital statistics. The graphic method employed in showing the increase of population is indorsed by one of the foremost statisticians of modern times, Dr. Newsholme, in his "Vital Statistics," third edition, 1899, pp. 246 and 265. It is believed that this method was first employed by Milne, in his construction of the Carlisle life table, about 1789. Theoretically, the compound interest or geometric method is correct, because it recognizes the fact that the *increase increases.* Practically, however,

there are limitations which show that the actual rate of increase in large American cities lies between arithmetical and geometric progression. The graphic method also has the advantage of bringing out sharply the defects of such a census as that of 1870. A very interesting inquiry is suggested by the allusion to the effects of the Civil War. Great wars have always had a decided influence on the vital statistics of the countries involved, and especially upon the death rates and marriage rates of years of war. The following figures illustrate this fact:

Austria.			France.			Massachusetts.		
Years.	Persons Married, per 1000.	Deaths, per 1000.	Years.	Persons Married, per 1000.	Deaths, per 1000	Years.	Persons Married, per 1000.	Deaths, per 1000.
1865	15.5	30.0	1869	16.5	23.5	1860	20.15	18.74
1866*	13.0	40.9	1870*	12.1	28.3	1861*	17.72	19.45
1867	19.3	29.2	1871*	14.4	34.8	1862*	17.69	18.45
			1872	19.5	22.0	1863*	17.36	22.15
						1864*	19.87	22.83
						1865*	20.62	20.64
						1866	22.14	18 14

* Years of war.

St. Louis appears to have suffered more severely than either New York or Boston in the cholera epidemics, and also in the great smallpox epidemic of 1872-73.

The comments upon the death rate from typhoid fever are worthy of special comment, especially the sentence beginning "But in view of the potency of sewage at short range." Undoubtedly, most of the great typhoid epidemics of recent years have arisen from "pollution at short range." Good legislation has decided influence in controlling the spread of typhoid fever. In Massachusetts, in the early half of the nineteenth century, the typhoid death rate could not have been below ten per ten thousand living. Only two cities of considerable size in the State were then supplied with public water, Boston and Salem, and this was sparingly furnished; but under the influence of rapid growth of towns and of legislation controlling water supplies and giving their general supervision to the State Board of Health, the typhoid death rate has been reduced as follows: In the decade 1856-65 it was 9.3 per 10,000; in 1866-75, 8.1; in 1876-85, 4.7; in 1886-95, 3.6; in 1896-04, 2.5. Fully ninety per cent. of the population now live in towns having public water supplies under State supervision.

There is yet another cause which has aided in the reduction of the general death rate in recent years beside the splendid effect of public sanitation, and that is immigration of great numbers of young

23

persons at healthy ages. The great mass of the population coming to our shores at the present time consists of young people between the ages of 15 and 35 years. These are distributed throughout the population of the States, and contribute to the reduction of the death rate, since the death rate of persons aged 15 to 35 is not more than 7 to 9 per 1000.

Mr. Allen Hazen.—Mr. Moore's very interesting statement as to deaths and causes of death in St. Louis is so complete that there seems to be little left to be said upon the subject.

The great increase in typhoid fever since the opening of the Chicago drainage canal is one of the notable features. Another point of great interest is that the reduction in the general death rate seems to be entirely in the deaths of children under five years of age, and that, excluding this class, the general death rate has not materially changed for many years.

It may be that a further analysis would modify this conclusion somewhat. That is to say, the death rate per thousand is high among very young and very old people, and is lower among those in middle life. It occurs to the writer that in the early years of the city the number of people in middle life was larger in proportion to the number of old people than it now is, and if so, an analysis of the results by age periods would perhaps show that the relative number of deaths of comparatively old people had increased and that the number of deaths of people in middle life had decreased. The writer has no direct evidence to support this theory, but it would seem that this matter should be investigated further before accepting the conclusion that there has been no change in the conditions affecting the death rate for that part of the population more than five years of age.

Dr. G. Baumgarten.—The co-operation of the sanitary engineer with the physician in the study of the life and health of the community is a characteristic and cheering feature of the modern development of the science of public hygiene. It is, nevertheless, a reproach to the medical profession that it was left to an engineer to undertake what a medical statistician should have done long ago. Warm thanks are due to Mr. Moore for this labor of love. The outcome of his analysis is of the greatest value to the community of St. Louis, especially as it is based upon a rationally corrected estimate of the population. The errors which still cling to this estimate probably can never be eliminated. A conspicuous one is apparent in the figures for 1849 and 1850: In the former year the great fire, the emigration to California during the gold fever and

the mortality by cholera alone of 4317 make it very improbable that the population had increased by 7260—*i. e.,* at a rate equal to the increase in the years preceding and following. Notwithstanding such details, the annual death rates here calculated can be utilized with confidence.

The same accuracy cannot be ascribed to the death rates of individual diseases, because the records of deaths from some of them are vitiated by faulty diagnoses. Thus the deaths from typhoid fever in the earlier years of this series are certainly understated, many being registered under other names, notably malaria, while they are more correctly recorded in recent years. Hence the annual death rate from typhoid fever can safely be said to have been greater than reported in the sixties and seventies, which makes the increase in 1882 to 1888 less abrupt than appears in the tables and its reduction in later years more satisfactory. Even in regard to consumption it is likely that many deaths were formerly reported under more innocent names.

The possibility of influencing the prevalence of pneumonia by such sanitary improvements as are within the scope of engineering science does not seem promising, and the death rate from this cause is increasing. It may be pointed out, however, that not only is this disease more correctly reported to-day than in former years, yielding larger figures, but since 1889 we have an additional source of pneumonia of the greatest importance in the annually repeated epidemic prevalence of influenza. The effect of this disease does not appear directly in the mortality records, because it becomes fatal only through its complications and sequelæ, and the deaths it causes are listed under the diseases of special organs and systems—pneumonia, heart diseases, kidney diseases and many others. But its value as a contributor to the general mortality cannot be overrated. This factor may well explain the rise of the death rate in 1890 to 1893.

Since it is impracticable, however, to "go behind the records," the tables which Mr. Moore has elaborated will probably stand as the authoritative vital statistics of St. Louis.

DR. JOHN GREEN.—The curve plotted by Mr. Moore illustrates the general trend of growth in great centers of population during the period which he has covered and, also, the effect of certain special causes which have notably retarded the growth of St. Louis during the middle decades of that period.

The general law of unrestricted increase in population, aptly designated by Mr. Moore as a case in compound interest, is exemplified in the curve as plotted from 1840 to 1860 and, again, from

1880 to 1900. For each of these periods the increasing steepness of the curve points to a growth, in geometrical progression, in which the annual rate is both very high and approximately constant. The effect of special conditions, interrupting the regular growth of St. Louis, is seen in the extreme flatness of the curve between 1860 and 1880.

The grossly overcharged enumeration of 1870 must be rejected as affording absolutely no guide to an estimate of the actual population of St. Louis in that year. As a check on this egregious fraud, the census taken by the city in 1866 is illuminating, but there is good reason for believing that its showing is somewhat below the truth. Possibly a very flat curve, approximating a straight line, connecting the points established for 1860 and 1880 and passing a little above the point indicated by the city census of 1866 to cut the ordinate for 1870 at about the point assumed in Diagram 1, thus smoothing out the small cusp shown at 1860, may represent the general flow of increase during this period with as near an approach to correctness as is attainable from the data at hand.

It would be interesting, were it practicable, to trace the fluctuations which must have occurred from year to year during the decade 1860 to 1870. That the opening year of the Civil War (1861) would show a notable depression scarcely admits of question. The remaining years of the war (1862 to 1865) were marked, on the one hand, by exceptional activity incidental to the establishment and maintenance of a great military depot and, on the other hand, by almost complete stagnation in building. The transition from war conditions to those of peace cannot have been altogether smooth, yet the city census of 1866 shows conclusively that the change was not attended by any remarkable disturbance.

Indirectly, the Civil War proved a most important factor in retarding the growth of St. Louis. The extension of great railway systems into new territory west of the Mississippi, involving a corresponding decline in river transportation, was already well under way in 1860. During the four years of the war the activity of St. Louis in the direction of readjustment to the rapidly changing conditions was suspended, to be resumed later at great disadvantage and with relatively tardy achievement. The progress made in this readjustment may be traced in an increased steepness of the curve, observable after 1880, and in the consecutive accessions in steepness after 1890.

The visible advances made since 1900 point to a continuing high annual rate of increase, as indicated in the tentative prolongation of the curve after 1900.

Passing to Diagram 2, in which the annual death rates are tabulated from 1841 to 1903, the year 1842 shows an unexplained low ratio of 26.67, as against an average of 52.44 for the decade and a half ending with 1855. Excluding the figures for 1842, the remaining fourteen years of this period show an average of 54.26, with fluctuations between the limits 38.14 and 120.30. These numbers point unerringly to the uncontrolled operation, between 1840 and 1855, of overwhelmingly unhygienic conditions, maintaining from year to year a fertile breeding ground for the propagation of pathogenic germs of many kinds, but all overshadowed by Asiatic cholera, which would appear to have been endemic during most of this period.

At 1856 the diagram shows a sudden reduction in the death rate, which was maintained through 1860; also a striking absence of conspicuous yearly variations from an average of 30.84. Cholera had disappeared, and there was a notable decrease in the deaths from typhoid fever. This was a time of active sewer construction, and the public water supply had been largely augmented and its distribution greatly extended. The growth of the residence section of the city westward, over previously unoccupied ground, an increased dependence on stored rain water in the place of that afforded by shallow wells, and a larger use of the then practically uncontaminated river water supplied by extensions of the city mains go far toward explaining the diminished ratio of mortality during this period.

The death rate (24.79) of 1861 is, with a single exception (23.08 in 1868), the lowest computed for any years of the first three decades (1841 to 1870) covered by Diagram 2. This low rate, tabulated between 30.96 for 1860 and 29.85 for 1862, may be interpreted as in support of other facts which indicate an actual decrease in population for this first year of the Civil War. The progressively higher ratios for 1862 to 1864, diminishing somewhat in 1865, find an explanation in the numerous deaths in the local military hospitals and in the great influx of refugees and negroes.

In the summer of 1866 St. Louis was visited by a grave epidemic of cholera, and the death rate for the year rises to 44.54. It was also a bad year for typhoid fever; in fact, the worst that has been recorded since 1854. In a less aggravated form the cholera was carried over to the next year, and sporadic cases occurred in 1868. Interpreted in the light of the medical knowledge of to-day, the facts observed during this epidemic afford a striking illustration of specific contamination of water drawn from shallow wells in polluted soil, which was still freely used in the older and more

crowded sections of the city and, although clear and pleasant to the taste, was, nevertheless, the principal vehicle for the dissemination of cholera germs, as it had long been for those of typhoid.

Since 1870 the sanitary conditions in St. Louis have been largely determined by the fact of the rapid extension of the city over new ground, outstripping the development of sewer systems and of water distribution; an extension stimulating and, in turn, stimulated by the extension of street railways and progressive improvements in methods of propulsion. A notable increase in the mortality of 1872, 1873 and 1875, due to epidemic smallpox and fluctuations in the death rate from typhoid fever, dependent on alternations of deterioration and improvement in the quality of the city water supply, teaches obvious lessons. The recently inaugurated work of the water department, in measurably clearing the distributed water of mud and living germs by coagulation and sedimentation, should bring about a diminution in the mortality from typhoid, and possibly some recognizable improvement in the general death rate of the city.

As the first to employ the graphic method in a comprehensive study of the vital statistics of St. Louis, Mr. Moore has shown the way to all future investigators in the same field of research. By no other method can the defects in recorded statistics be so clearly demonstrated, and, in certain cases, approximately corrected. As remarked by Prof. Henry S. Pritchett, in discussing the population curve plotted by him for the United States from the decennial census reports down to 1890, a prolongation of the curve affords the most trustworthy general guide for estimating probable future growths for periods of a few years. For purposes of interpolation throughout the intervals between periodical enumerations it is unquestionably the surest, as it is the simplest, method known.

Mr. Robert Moore.—The author is much gratified by the general concurrence of those who have discussed his paper in the methods used by him in his investigation. The concurrence of such men is a sure indication of what must be the general verdict.

The author also recognizes the justice of what has been said by way of criticism and qualification of some of the conclusions indicated by his investigation. These qualifications, however, are all due to omissions and imperfections in the data which are now beyond remedy. The age distribution of the population, particularly in the first three decades, cannot now be determined; nor can errors in regard to the causes of death be now corrected. We must make the best of such data as we have.

But while due allowance must be made for these imperfections, the main conclusions of the paper remain unshaken.

THE CLASSIFICATION OF ENGINES FOR BRIDGE LOADING.

By C. D. Purdon, Member of the Engineers' Club of St. Louis.

[Read before the Club, October 19, 1904.*]

This is more in the nature of a device for saving time and labor than a paper for a scientific club.

Upon any railroad of mature years there will, no doubt, be many iron or steel bridges of varying degrees of strength, having been built at different times, under different specifications and for different loadings. As the engines have maintained a healthy growth for many years, it is likely that some of the older bridges will be found rather light to carry the newer engines in regular service, although occasional trips may be safely allowed.

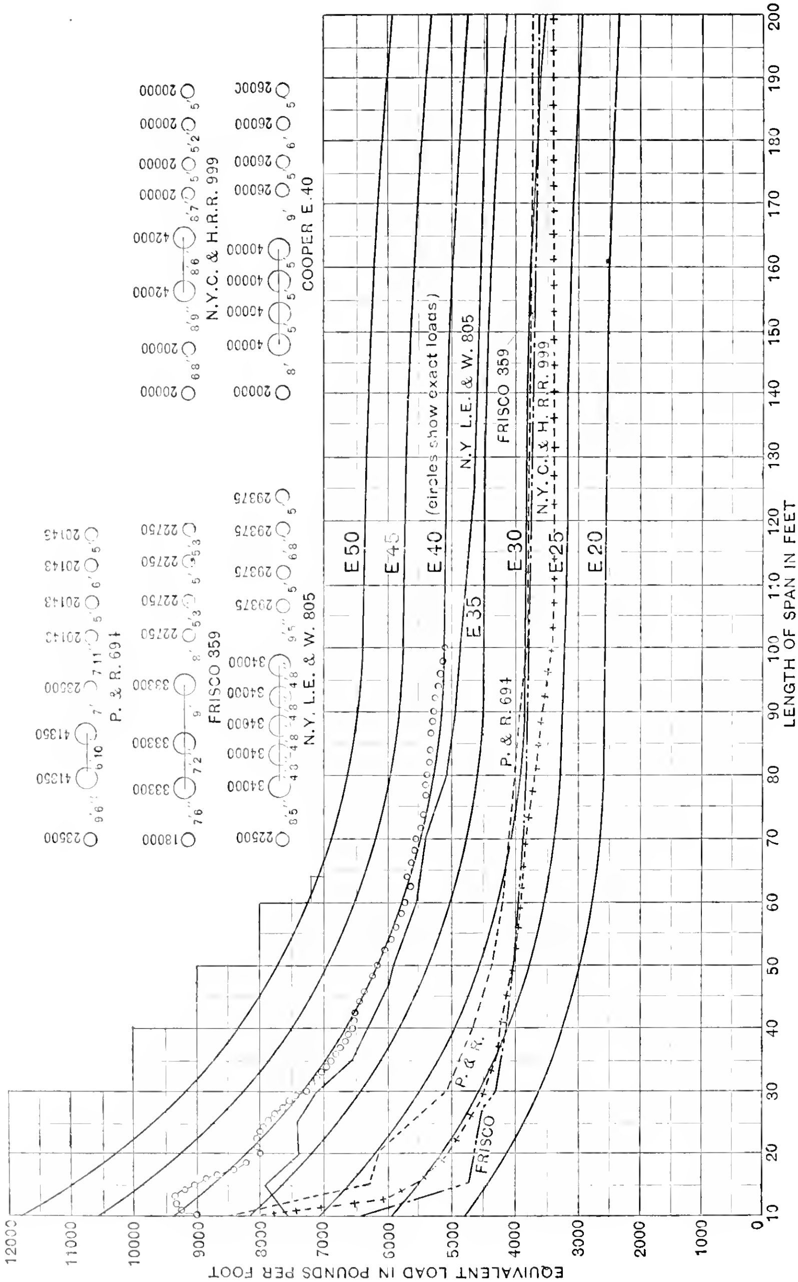
For this reason the receipt of messages from the operating department, asking whether engine number so and so can be run over such a division, "please reply by wire," is very common.

As an answer entails first getting the detailed weight and wheel spacing of the engine and then calculating more or less bridges for it (the original strain sheets having, in many cases, disappeared), it is very evident that some means of comparing the strength of the bridges with the weight of the engines is desirable, so that such questions can be readily answered and the superintendents furnished with lists showing what engines, if any, are barred from certain districts.

To attain this result the writer decided to classify the engines in use according to Cooper's specifications for bridges, the loadings varying by regular percentage, and to calculate all bridges for class 40; then, having the strain in any member induced by the loading of class 40, a simple proportion gives the strain for any other loading.

All of the engines in use are classified, and each new engine is classed as received. This is done by calculating the moments for the concentrated loads for different lengths of spans and then finding the load in pounds per lineal foot which will produce the same moment. Taking as typical spans deck girders up to 90 or 100 feet in length and truss spans for greater lengths as the moment is equal to the weight per foot, multiplied by the square of the length in feet and divided by eight, it is a simple matter to find the equivalent load by multiplying the moment by eight and dividing by the square of the length.

* Manuscript received November 7, 1904.—Secretary, Ass'n of Eng. Socs.



Classification of Engines for Bridge Loading. Diagram Showing the Equivalent Load in Pounds per Lineal Foot which Produces the Same Moment as the Engines. One-Third of Full Size. The Original Diagram is Divided to 1 Foot of Span and to 100 Pounds of Load per Foot.

For truss spans the panel coefficient is used. This may be found in Waddell's "De Pontibus," page 370; for instance, in a five-panel truss the moment in the center panel of bottom chord is three panel loads; therefore the equivalent load is the moment divided by three times the square of the panel length.

A diagram of Cooper's different loadings is prepared, showing a curve for each loading, varying by five; by platting on this diagram the equivalent loads for any engine, the class of the engine is at once shown.

The drawing attached shows this diagram, showing loadings 25, 30, 35, 40, 45 and 50. These were platted by taking the equivalent loads for class 40 from the table in the American Bridge Company's specifications, platting the loads as shown by the small circles and averaging them with a curve. The other loadings are proportional to 40.

Upon this drawing are shown the weights and wheel spacing of a few engines of different types for illustration, the equivalent loads being shown on the diagram.

Engine 999, N. Y. C. & H. R. R., would be class 40 on very short spans, falling to class 25 at 16 feet, and remaining in this class up to nearly 40 feet, then remaining about class 27.

Engine 694, P. & R., is practically class 30, except on very short spans.

Engine 359, Frisco, begins with class 33, falls to 22 at 15 feet, rises to 25 at 40 feet and 30 at 90 feet and over.

Engine 805, N. Y., L. E. & W., runs between 30 and 40.

It is evident that any number of classes can be made—practically advancing by five will be sufficient, except perhaps for classes over 30, when closer figures may be desirable.

Having the engines classified, a list of the bridges on each freight division—now known as a "district"—is made, giving the number, length and a very brief description, together with the strain per square inch induced in the weakest member by loading 40.

A short inspection of this list, with the class of the engine, will give the strain in the weakest member.

It is hardly necessary to say that the number of the loading in Cooper's specifications means the weight in thousands of pounds on each driving axle. For instance, class 40 has 40,000 pounds on each of four axles, class 30 has 30,000, etc., the wheel spacing in each case being the same and all other axle loads being in the same proportion as the driving axles.

A list is furnished each superintendent, trainmaster and dispatcher, showing the class of every engine, and the heaviest class

to be used in regular service on any district, the latter divided into two columns; one column giving the class as limited by iron bridges, the other the class as limited by trestle bridges.

This list fixes the heaviest class for regular service. If for any reason it is desirable to move a heavier engine over any district, the superintendent wires for information. With the list and diagram an answer is readily given.

Unfortunately there is no royal road to classify the engines—each one has to be calculated by itself—though in many cases there is sufficient similarity to classify one engine by comparison with others already classified.

The writer calculates moments for each 5 feet in length up to 50 and each 10 feet 50 to 90 feet, taking the center moment of a beam or deck girder; beyond 100 feet in length the center panel moment of bottom chord in truss spans of 25-foot panels, increasing by one panel length, or 25 feet.

While a good deal of labor is necessary for these calculations, when once made in this shape they are always available for instant reference, so that in the end time is saved.

This method of classification meets with the approval of all departments of the system with which the writer has the honor to be connected, and the mechanical department give the bridge class of engines in all their lists, so that all parties are advised of it.

A sample sheet of bridge list is given below, merely to convey the idea. It is evident that to find the effect of any engine on these bridges its class on a 12-foot span for bridge 96, and 18-foot span for bridge 122, would be the governing weight.

Bridge List.—Omaha District, Western Division.

Number.	Length.	Description.	Strain per Sq. Ft. Class 40	Remarks.
82	40	Deck girder	9,200	
96	62	Through-girder, 5 panels	11,000	On stringers.
118	40	Deck girder	9,800	
122	160	Through-truss, 9 panels .	10,500	Hip vertical; pins small and worn.

Trestles, 14-foot panels; stringers, 2 panels, 8″ x 18″. Fibre strain, 1450 from class 40.

OBITUARY.

Charles William Folsom.

MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

CHARLES WILLIAM FOLSOM was born in Cambridge, Mass., April 17, 1826. After attending various schools in his native place he entered Harvard College at the age of fifteen, and was graduated there in 1845, receiving the degree of A.B. Among his classmates were the late George P. Bond, Director of the Astronomical Observatory, and Horace Gray, Associate Justice of the United States Supreme Court.

From 1845 to 1848 he was acting civil engineer for the Essex Company, at Andover, being associated

ERRATUM.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, Vol. XXXIII, No. 5, November 1904, page 328, table at foot of page (Bridge List), heading of 4th column. For Strain per Sq. Ft., Class 40, read Strain per Sq. In., Class 40.

On the outbreak of the Civil War he received a commission, July 1, 1861, as quartermaster in the Twentieth Massachusetts Volunteer Infantry, of which Wm. Raymond Lee was then colonel, and the lamented Gen. W. F. Bartlett was then a captain. He was in many engagements and often under fire, though at all times acting as quartermaster,—at one time as brigadier quartermaster of the Third Brigade, Second Division, Second Corps. March 13, 1865, he was promoted to captain and assistant quartermaster United States Volunteers, and brevetted colonel. Among his comrades there are told many stories of his unofficial kindness and his unusual application to his duties. From May to November, 1865 he served as chief quartermaster of the district of the Nottoway, Virginia, in the Department of Petersburg; and he continued in the army for three years afterwards, until his honorable discharge, August 31, 1868, his last duties being in the office of the quartermaster-general, United States Army, Washington, D. C., where he had charge of the

Department of National Cemeteries. He had the unanimous indorsement of all his superiors, up to and including Quartermaster-General M. C. Meigs, for transference to the United States Service.

In 1869 he was receiver for the Alexandria, Loudon & Hampshire Railroad Company, in Virginia, and of the East Tennessee & Virginia and the East Tennessee & Georgia Railroads, in Tennessee. In 1870 he was assistant engineer of Boston, and for three years thereafter superintendent of Mt. Auburn Cemetery.

From 1873 until recently he was employed in the sewer department of the city of Boston, except that in 1881 he was principal assistant engineer of the Elk River Railroad, in West Virginia, under the late Thomas Doane, and in 1885 he was for a time employed as an engineer by the Massachusetts State Commission on Drainage and Water Supply of the Charles and Neponset Rivers.

His principal work for the Sewer Division of Boston was the preparation of topographical maps, from original surveys, of the outlying districts Dorchester, West Roxbury and Brighton. These maps are the best in the department, and practically the only complete ones, and are relied upon in the design of new systems of sewers and in the settlement of disputes and suits in which the determining consideration is the original location of natural water courses.

He also projected and superintended the construction of the most important main sewers and surface drains in these districts, and had charge of the general engineering work of a district.

He died in Cambridge, May 19, 1904, and was buried at Mt. Auburn.

Col. Folsom, as he was always called, took great interest in the affairs of the Boston Society of Civil Engineers and was a frequent attendant at its meetings.

His reputation for skill and accurate work in his profession was very high, and his subordinates will also gladly bear witness to the patience and consideration he showed them in their various relations.

A man of literary as well as scientific tastes, he was always a pleasant companion, having a fund of general information and knowledge of many interesting people.

Too modest to obtain the highest prizes of this world, he deserves to be long remembered for the strict integrity of his character and his unselfish and unblemished life.

Charles W. Kettell,
W. H. Bradley,
Edgar S. Dorr,
Committee.

Editors reprinting articles from this journal are requested to credit not only the JOURNAL, but also the Society before which such articles were read.

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THE WATER SUPPLY OF MINNEAPOLIS.

BY J. FRANK CORBETT, M.D., BACTERIOLOGIST, MINNEAPOLIS BOARD OF HEALTH; PROFESSOR OF BACTERIOLOGY, HAMILINE MEDICAL COLLEGE.

[Read before the Engineers' Club of Minneapolis, October 10, 1904.*]

BEFORE coming to the discussion of the subject of this paper it is important to explain the relationship between colon bacilli and typhoid bacilli. The cause of typhoid fever, the typhoid bacillus, is present in the intestinal dejecta and the urine of typhoids. As typhoid is a very common disease, any water containing fecal matter is liable to contain typhoid bacilli. These bacilli are capable of living for a long time in water. If such water be drunk, typhoid fever is the result. Statistics have shown that the drinking of a water constantly contaminated with human fecal matter invariably results in typhoid fever. The amount of sewage may be imperceptible to any of our senses. A single case of typhoid fever has infected the water supply of a whole city by depositing dejecta on the shores of a reservoir.

The typhoid bacillus is difficult to demonstrate in water, but if fecal matter be present in water, so universal is typhoid, the water is not fit for use.

As the colon bacillus is derived only from the intestinal contents, bacteriologists assume the presence of colon bacilli to indicate fecal contamination.

The water supply of Minneapolis is derived from the Mississippi River. There are four pumping stations. Two of these—the North Side Station and the Northeast Station—are located at the

* Manuscript received October 21, 1904.—Secretary, Ass'n of Eng. Socs.

outskirts, before the river enters the city. The water from these stations receives little or no direct contamination from our own city. The lower stations are known as the East and West Side Stations. These lower stations are located in the heart of the city and receive the water below the outfalls of several large sewers. Both lower stations have been closed by the Water Board.

In Minneapolis, colon bacilli are constantly found in the water of the lower pumping stations, and occasionally in the water from the upper stations. A chart prepared by Mr. F. W. Cappelen shows an increase of typhoid during the years when the lower stations were used, and a decrease when they were not used. Dr. P. M. Hall has also collected statistics showing the water supply from month to month and the invariable rise of typhoid following the use of the East and West Side water.

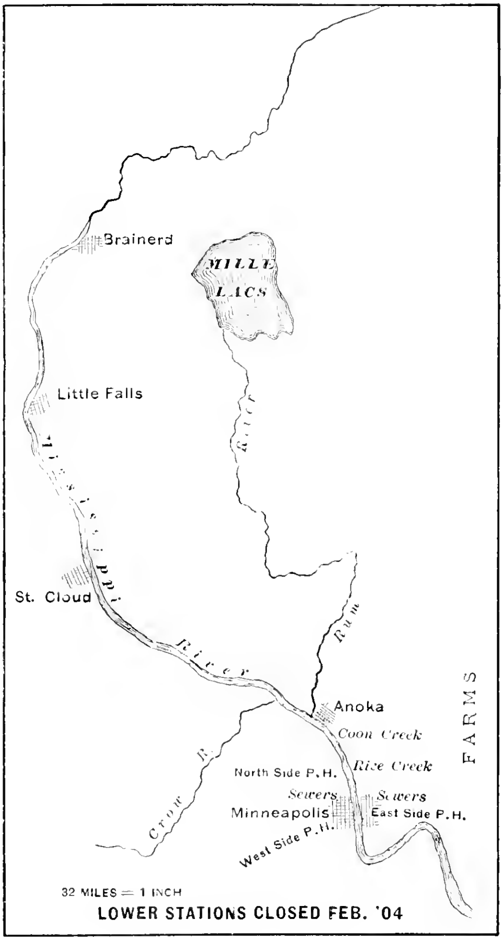
In chart No. 1 the black line represents the number of deaths from typhoid for each month from January 1, 1903, to September 30, 1904. The dot and dash line represents the amount of water supplied from West Side Station; the underscored dotted line indicates the amount of water from the East Side Station.

It will be seen that following the use of the East Side Pumping Station there is an immense rise in the typhoid line. An analysis of the cases shows that the typhoid was almost entirely in that portion of the city supplied by the East Side pumps. Before this, when the West Side pumps were running, the preponderance of cases had been on the territory supplied by the West Side water. When the West Side Station was closed and the North Side water turned on, the typhoid diminished in the same area. Also after the East Side pumps were stopped and North Side water supplied, the typhoid diminished in the East Side area. This shows the water from the lower stations to be a prolific source of typhoid.

Further analysis of the chart shows that we had a considerable rise of typhoid fever cases in February and March of 1903. As no water had been pumped from the lower stations for four months, we cannot charge this increase to them. These cases must have originated either from the North Side water, or from contaminated wells. That the North Side Station was responsible at that time is probable from the fact that above our pumping station in the Mississippi River are located Anoka, Little Falls, St. Cloud and Brainerd. Except Anoka, all these cities have sewers emptying into the Mississippi River, and typhoid was prevalent in these cities before that time. Further than this, the cases were largely in a portion of the city that uses river water. General distrust in city water has resulted in many surface wells being used. In 1898,

1899 and 1900, over 50 per cent. of typhoid came from the use of well water. The action of the Board of Health in closing these infected wells has diminished the return from this source.

In February, 1904, a commission, consisting of Messrs. Cappelen, Rinker and Hazen, was appointed to investigate the water supply of Minneapolis. The writer of this article was requested by



the commission to make certain analyses. The results of these analyses have been incorporated in the accompanying charts.

Chart No. 2 shows the relative number of bacteria in river water and in the same water after being allowed to sediment in the reservoirs. From this it is seen that sedimentation removes a considerable per cent. of bacteria, and tends to diminish the number of

colon bacteria. The colon bacilli are found much more frequently in the river water than in the reservoir. Originally on this chart we represented analyses from both upper stations and the upper bay. As these analyses gave results almost identical on each and every day, we represent only one station on the chart.

In chart No. 3, we have represented the analyses of water taken from various parts of the Mississippi River. The height of columns indicates total number of bacteria per cubic centimeter; the lighter gray columns indicate the absence of colon, the black columns the presence of colon bacilli. From this it will be seen that there is no material change in the water until we reach Brainerd, and that there is a direct rise in the number of colon bacilli as we pass cities and towns, and that they tend to disappear as we recede from centers of population. This diminution is not due to mere mechanical agitation, but probably to dilution and to action of algæ, etc.

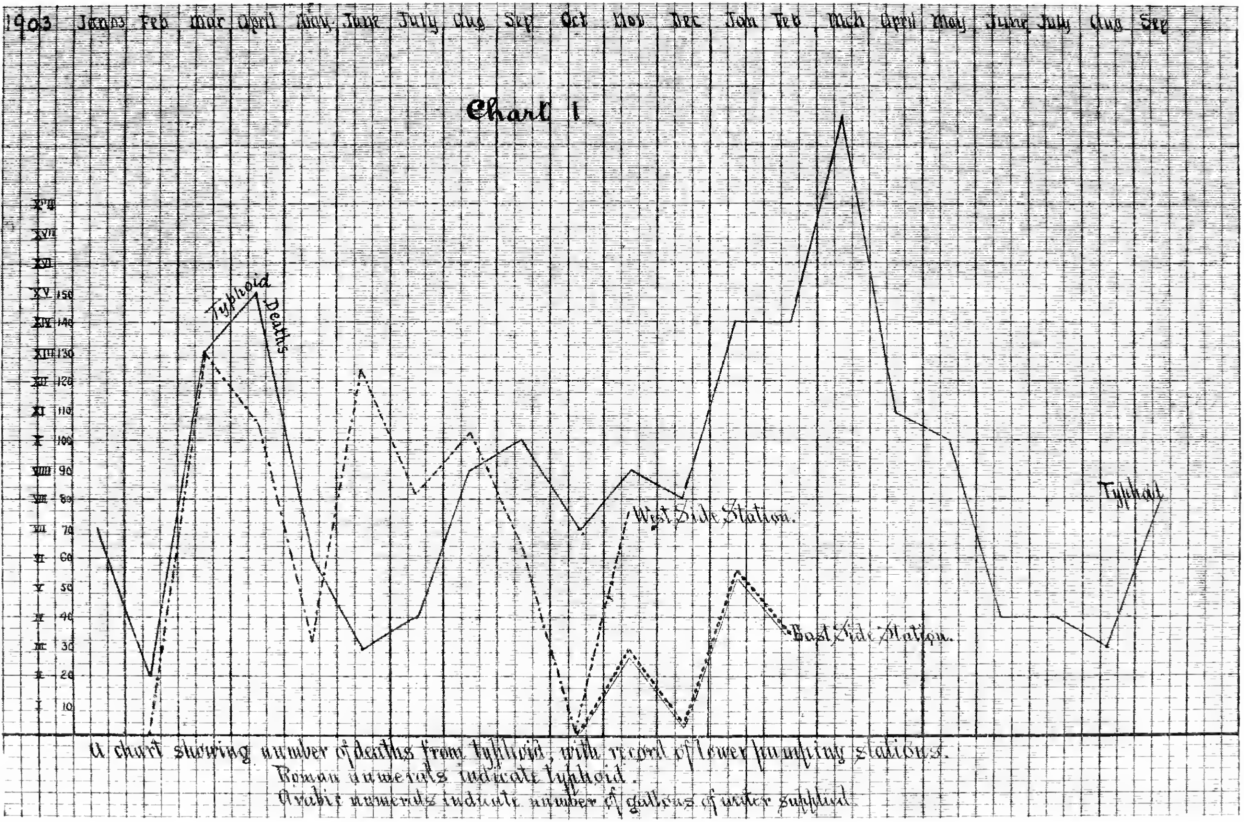
There is an immense rise in the total number of bacteria when we reach the lower stations. The colon bacilli can be demonstrated in the very smallest amount of water used from this location.

In this chart are represented, also, the analyses of the tributaries of the Mississippi. In the Mille Lacs analyses we find very pure water in the main lake. In the bays and near the shores we find already slight contamination, as indicated by presence of colon. This region is being rapidly settled and the amount of contamination is bound to increase. Although Mille Lacs is a beautiful body of water, 30 miles across and sufficiently deep, yet close settlement would render it unfit for use. In addition, the presence of certain algæ in the water presents a serious problem. It has been found that the presence of these algæ in water render it unpleasant on account of odor. They ordinarily exist in small numbers and do not cause trouble, but when put under proper conditions they multiply and are a source of annoyance. The storage of water in shallow reservoirs favors their development in certain seasons. It is possible that certain traditions of dead fish, causing the lake to smell, may be due to these algæ.

We isolated the following species, which in large numbers give rise to disagreeable odor:

Clathrocystis,
Anabaena,
Oscillatoria,
Asterionella,
Navicula.

The outlet of Mille Lacs is the Rum River. The Rum River remains tolerably free from contamination until it reaches Anoka.


1903 Jan 03 Feb Mar April May June July Aug Sep Oct Nov Dec Jan Feb Mch April May June July Aug Sep
Chart 1
Typhoid Deaths
West Side Station.
East Side Station.
Typhoid
A chart showing number of deaths from typhoid, with record of lower pumping stations.
Roman numerals indicate typhoid.
Arabic numerals indicate number of gallons of water supplied.

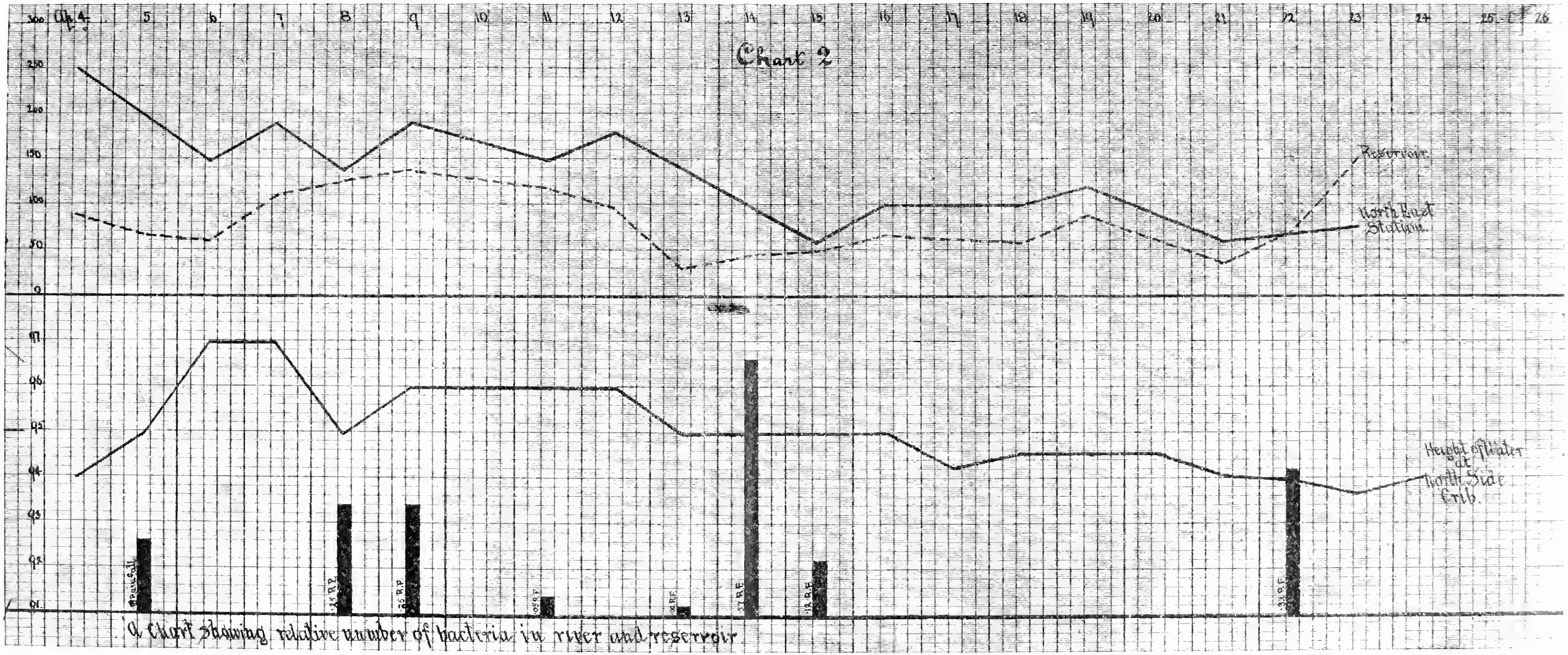
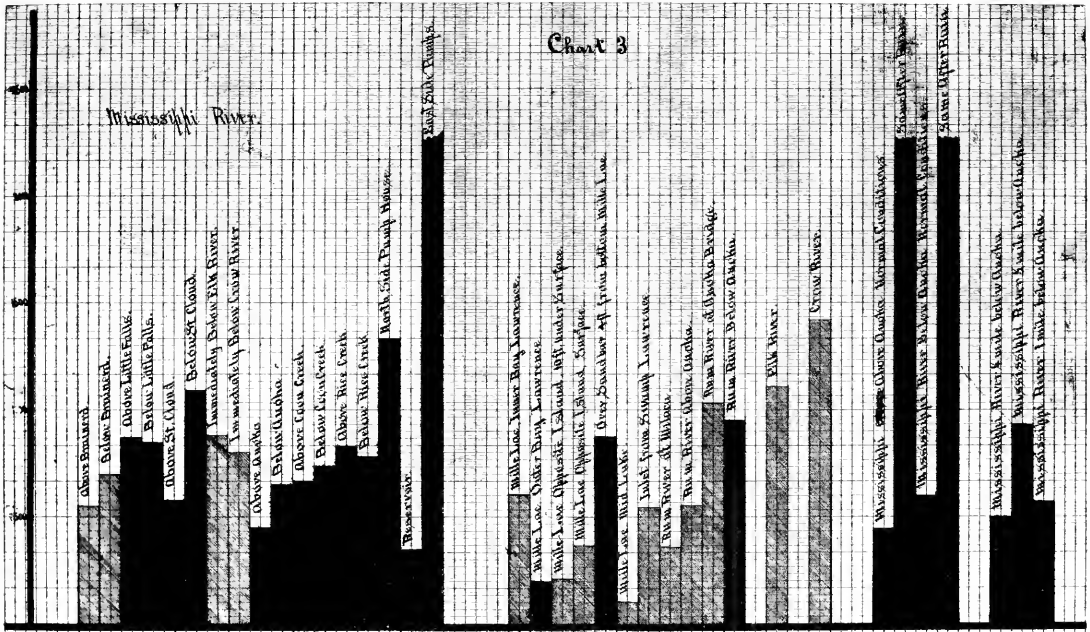


Chart 2
Reservoir
North East Station
Height of Water at North Side Crib
A Chart showing relative number of bacteria in river and reservoir



A CHART SHOWING RESULTS OF BACTERIOLOGICAL ANALYSES OF WATER.

Height of Columns Indicates Total Number of Bacteria per Cubic Centimetre.

Black Indicates Colon Bacilli.

Although Anoka has no sewer system, it is apparent from the charts that the refuse is washed into the Mississippi River by rains. In the next to the last series the effect of this is shown. After heavy rains the water is much more highly contaminated than before. This statement is based on samples of water collected on six different dates. It should therefore be reliable. In the Mississippi River, above Elk River, only one set of samples was collected. Below this point the charts represent a series of six different expeditions.

The analytical work was done by Messrs. Swinnerton, Woodworth and Corbett.

A RECENT VISIT TO TWENTY-FOUR BRITISH SEWAGE WORKS.

By M. N. Baker, Associate Editor of the Engineering News.

[Read before the Sanitary Section of the Boston Society of Civil Engineers, October 12, 1904.*]

Mr. Chairman and Members of the Sanitary Section of the Boston Society of Civil Engineers: It was my great pleasure, shortly before I left this country for England, to attend the session of your section at which you discussed the septic tank and its relation to sewage disposal. I was very glad indeed to have that opportunity to hear from so many of the most experienced men in this country—the brightest minds in sewage works practice—immediately before going abroad to study the same general subject. It helped to freshen and inform me in regard to American conditions and has made it much more profitable for me to compare American and English practice.

On receiving the request to be with you to-night, I supposed that an informal talk was expected, but later I saw that the notices for the meeting read that I would present a paper. I propose to compromise by presenting a portion of what I have to say from a manuscript and supplementing it with more informal remarks.

I shall be glad to answer any questions, even in the progress of what I have to say, if it will add to the clearness of my subject.

Having been given a roving commission to go abroad for the general purpose of studying municipal conditions, I found it profitable to devote most of my time to British sewage purification works. Well provided with letters of introduction, I arrived in London on March 8, 1904. In that city I spent several weeks calling on a number of men and getting my bearings. On March 9 I called on Dr. Samuel Rideal, a leading chemist, and author of one of the best British books on sewage treatment by the later methods. He gave me a hearty welcome and some notes of introduction which proved of great service to me. Mr. Arthur J. Martin, one of the three engineers who introduced the septic tank in England, received me most kindly that same day and did much for me while I was abroad.†

* Manuscript received November 21, 1904.—Secretary, Ass'n of Eng. Socs.

† Mr. Martin, I may interject, was in this country for several years, in Schenectady, and he spoke very kindly of the treatment accorded him by the American engineers and others; and he, as well as a number of other persons whom I met, expressed themselves as wishing to do what they could for me, because they had been so kindly treated by Americans when they had been in this country.

I remained in London more than two weeks, meeting Mr. W. J. Dibdin, who developed the contact bed, and Dr. Frank Clowes, chemist of the London County Council, who succeeded Mr. Dibdin in that office and carried on the famous London experiments on the treatment of sewage in septic tanks and contact beds. Later and elsewhere I met Mr. Donald Cameron, of Exeter; Dr. Gilbert J. Fowler, of Manchester; Mr. John D. Watson, of Birmingham; Lieutenant-Colonel Alfred Jones, of the Aldershot Camp Sewage Farm, and many other engineers and chemists who have contributed largely to the progress of sewage treatment in Great Britain.

The twenty-four sewage works which I visited while in Great Britain ranged in size from the two plants which treat the sewage of the County of London, with its 4,500,000 people, to the small works of the Sandhurst Military Schools, serving about 1000 persons. Nine of the places visited had populations of more than 100,000 each. While I saw only a few of the numerous municipal sewage works in Great Britain yet 8,500,000 people were tributary to those works. In contrast to these figures it may be noted that Mr. George W. Fuller stated in his recent paper before the International Engineering Congress that there are about 1,100,000 people tributary to the sewage purification works of the United States.

The methods of treatment which I saw included plain sedimentation, chemical precipitation, broad irrigation, straining, intermittent filtration, the septic tank, contact beds and percolating filters, some alone but mostly in combinations of two, three or more processes. Scarcely any two plants were alike; or, to put it otherwise, there were family resemblances only. The works most closely resembling each other were those depending wholly upon either chemical precipitation or broad irrigation, or else the three built under agreements with the Septic Tank Syndicate. On every hand, new or modified processes had been or were being tested on an experimental or a working scale. Most of the works installed years ago had changed or were changing to some one or more of the so-called bacterial processes, and most of the recently conceived works were of the same kind. But I expected to find, and did find, a notable proportion of works true to the old British tradition of either chemical precipitation or sewage farming, notwithstanding the hurrah over septic tanks, contact beds and percolating filters. Sewage farming, I should say, has been less shaken by the new methods than has chemical precipitation. At least, chemical precipitation appears to be more a matter of toleration than does sewage

farming; the latter, where already in use under naturally favorable conditions, not being so eagerly abandoned as the former for some new process.

One important fact that should be borne in mind by those who are considering the newer methods of sewage treatment in England is the enormous difference in the soil of England and America, and particularly this part of America. English engineers have been absolutely driven into seeking other means of treating sewage than applying it to land, because the land is so very unsuitable for the purpose of sewage treatment. Those of our American engineers who have been abroad and familiarized themselves with foreign conditions have come back to this country quite conservative about recommending the introduction of British methods. Some of our American engineers who have not been abroad, but have confined themselves to reading literature on the subject presented in the English journals—literature usually in the form of papers read before the various sanitary and other associations and often by advocates of particular processes—have had a tendency to be carried further by the foreign practice than those who have been abroad, and therefore it seems to me that they have recommended the introduction of some kinds of British treatment in places where they were not called for, and where probably American lines of treatment would have been more suitable. In many of the densely populated districts of England, sandy soil is notable by its absence, and the clayey soil on which the people of that country try to treat sewage is enough to appal any engineer. The manner in which they have constructed and operated some of those works really fills one with admiration that men could contend so successfully against such odds.

The most marked impression made upon me, particularly during the first part of my stay in Great Britain, was that nothing regarding sewage purification in that country seemed to be generally accepted as settled. True, a large number of people look upon both chemical precipitation and sewage farming as things of the past, quite superseded by the so-called bacterial processes; but if you visit British sewage works at random, you will find many sewage farms and chemical precipitation plants still in use, and, as to the newer processes, no agreement even among their friends as to which is the best. Examine septic tanks and you will find some open and some closed (although the open ones seem to be most in favor) and no common practice as to frequency of cleaning and means of sludge disposal. With contact beds and percolating filters there is

even more dissimilarity and uncertainty in design, choice of material or medium, method of operation and unit rate of working.

Such confusion in theory and practice came as a surprise to me. I had not expected to find everything settled, but I looked for some prospect of agreement as to both methods and details of carrying them out.

The more I have reflected upon what I saw, the more I have come to believe that the confusion in British practice is more apparent than real; that, so far as it exists, it relates more to minor details than to essential processes; that the multifarious differences in detail may be largely attributed to the fact that there are many ways of achieving the same end and also to the mastering desire of the British health officer, chemist and engineer (particularly the first and second) to become known as an originator of a new method of treating sewage.

My early impressions of confusion abroad will be excused, I trust, as I review, in chronological order, the works I visited in Great Britain. After I have regrouped the works by the only classification of processes I have yet dared to attempt and made some comments on my summaries you will see how my ideas have, as I hope, become somewhat clarified.*

The accompanying table presents, in chronological order, the sewage works visited, their tributary population, and a condensed statement of the method of purification employed. The latter is, in many instances, incomplete and in some cases misleading, because of the variety of methods in use and the changes in progress. I shall now attempt to bring out some of the most interesting features of the various works.

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* I have elsewhere summarized what I found at most of the British works visited, arranging the summaries in order of population of the cities and towns concerned. (*Engineering News,* April 21, 1904.) In still another place I have described at length all the works visited, grouping them in accordance with the method of final treatment employed. ("British Sewage Works, and Notes on the Sewage Farms of Paris and on Two German Works"; published in October, 1904.) For the sake of variety and interest, I here take up in chronological order the several British works visited, and to avoid repetition of matter fully presented in my book, I make little use of statistics and of detailed descriptions.

British Sewage Works Visited, with Tributary Populations and Methods of Treatment Employed.

London	4,536,000	Chemical Precipitation.
Sutton	17,000	Septic Tanks and Contact Beds.
Reading	72,000	Sewage Farming.
Sandhurst Military Schools	1,000	Sewage Farming.
Aldershot Camp	25,000	Sewage Farming.
Aldershot Town	17,000	Contact Beds followed by Intermittent Filters.
Birmingham and District	793,000	Settling Tanks, Septic Tanks, Dortmund Tanks and Percolating Filters.
Salisbury	18,000	Septic Tanks, Percolating Filters and Rapid Secondary Filters.
Exeter	48,000	Septic Tanks, Contact Beds and Land Treatment.
Yeovil	14,000	Septic Tanks, Contact Beds and Land Treatment.
Manchester	545,000	Chemical Precipitation being replaced by Septic Tanks and Contact Beds.
Salford	220,000	Chemical Precipitation, Roughing Filters and Percolating Filters.
Rochdale	84,000	Roughing Tanks, Chemical Precipitation, Contact Beds, Percolating Filters and Land Treatment.
Chadderton	25,000	Chemical Precipitation and Contact Beds.
Oldham	140,000	Sedimentation and Contact Beds.
Accrington and Church	50,000	Septic Tanks and Percolating Filters.
Burnley	97,000	Sedimentation, Septic Tanks and Contact Beds.
Glasgow	780,000	Chemical Precipitation.
Barrhead	10,000	Septic Tanks and Contact Beds.
York	78,000	Chemical Precipitation and Percolating Filters.
Leeds	444,000	Chemical Precipitation.
Nottingham	240,000	Sewage Farming.
Leicester	200,000	Sewage Farming.
Hampton	7,500	Hydrolytic or Septic Tank and Contact Beds.
Total	8,461,500	

I will now try, without going too much into detail, to bring out the more interesting features of these works.

At London are the largest sewage works and the largest chemical precipitation plants in the world. The two plants are treating very nearly 300,000,000 United States gallons per day by chemical precipitation. Plans, however, are being made to abandon chemical precipitation. I think that there is some difference of opinion among those in authority in London as to the advisability of carry-

ing out the scheme recommended in the recent summary of reports published by Dr. Clowes, of London. Dr. Clowes and Mr. Worth, one of the engineers in charge of the London sewerage system, both informed me, as I understood them, that it was practically settled that as soon as possible septic tanks and contact beds would be established. I made this statement in a letter that I wrote for publication in this country. But subsequently Mr. Fitzmaurice, Chief Engineer to the London County Council, wrote a very sharp letter denying that they were committed to these new processes. New methods of sewage treatment have been under discussion in London a great many years, and it may be that they will continue to be discussed for some years to come.

I had a very interesting experience in going to visit the London works. I was taken down the Thames in the "Beatrice," a steamer owned by the London County Council, in company with the chemist in charge of one of the works. Every week some representative of the London County Council takes this trip down the Thames from London Bridge, or thereabouts, to Barking and Crossness and even further down the river. At frequent intervals samples of the water are taken and analyzed on the boat. This practice has been kept up weekly for a number of years, thus accumulating data regarding the changing conditions, if any, of the Thames, both above and below the present sewage works.

At Sutton, as many of you know, Mr. W. J. Didbin has a residence, was at one time on the local town council, and put in the first, or about the first, contact beds. He was carrying on investigations at the time for London, and put down these contact beds to treat the flow of the sewage by this method alone. Later, and independently of Mr. Dibdin, what he calls grit or detritus chambers have been built. Curiously to me, and I think to most of you, Mr. Dibdin urged that inasmuch as the patented methods of the Septic Tank Syndicate were not followed at Sutton it was wrong to apply the term "septic tanks" to those tanks; but the foreman of the works called them septic tanks, septic action was in progress, and I call them septic tanks, although in my book on "British Sewage Works" I put in a footnote explaining Mr. Dibdin's attitude on the subject.

Additional contact beds were being constructed at Sutton at the time of my visit, but on somewhat different lines from those that Mr. Didbin had employed; that is, they were putting in triple contact beds, arranging to pass the sewage successively through three sets of beds and have a total fall of only some 18 inches from the point of entry to the first bed to the discharge from

the last one; and they were using, as is commonly used at many places, automatic apparatus for controlling the discharge from one bed into another. The changes and extensions at Sutton have been and are being carried out by Mr. C. Chambers Smith, surveyor to the Sutton Urban District Council.

At Reading I saw a large sewage farm which seemed to be well operated so far as sanitary conditions were concerned, but which was in a bad way financially. The authorities had been so absolutely confident of making money out of sewage farming that for years they had carried a deficit in their accounts instead of writing it off to profit and loss, expecting to make it up in time. But within the last year or so Lieutenant-Colonel A. E. Jones, of Finchampstead, Berkshire, who is a strong advocate of sewage farming, and Mr. Avis, manager of a large sewage farm which I visited at Nottingham, and another gentleman who is a farmer, have been appointed as an advisory committee to help the Reading people put the sewage farm on a better financial basis.

The Sandhurst Military Schools have a neat sewage farm of 13 acres. The sewage is received in small detritus tanks with sloping bottoms. The sewage runs into the upper end and flows down over the sloping bottom, and then overflows from the tank. In that way, grit, sand and the like are taken out and the land is relieved to some extent. An old man there was attending to the sewage farm, without any help further than a gypsy boy to scare off blackbirds from newly sown grain. At the time of plowing and cultivating, horses and men are brought over from the Aldershot sewage farm, which is also under the charge of Colonel Jones, to aid in the work.

Aldershot Camp has a large population, both of men and of horses. It is one of the large military camps that one finds everywhere in England. This camp has a varying population of from 20,000 to 30,000 men, and there are many thousand horses there at times. The stables are drained to the sewage farm. The Aldershot Camp farm was in very bad repute for a number of years and there was a strong effort made to secure its abandonment; but Colonel Jones took hold of the matter and by handling the farm in an engineering way he has stopped pondage, and has everything in good shape. Although there is a hospital overlooking the farm there is no complaint. He has no trouble in disposing of the milk from the farm. The cow barns were in very fine sanitary condition. A record of the milk produced by each cow is kept. Colonel Jones makes a monthly report on the operations of the farm. When he balances his books at the close of the year he considers the deficit as the net cost of sewage disposal.

At Aldershot Town there was originally quite an area in land treatment. The sewage is now received in large reservoirs and pumped to contact beds. From the contact beds the sewage goes to still another set of beds which are operated as intermittent filters, and there is land still in use for the reception of the storm-water.

Birmingham and vicinity, including some 800,000 population, has one of the largest and most interesting of the sewage works in Great Britain. A number of municipalities are combined as the Birmingham, Tame and Rea Drainage District. Mr. John D. Watson is engineer of the board. Mr. Watson went to Birmingham about 1900. He found chemical precipitation followed by broad irrigation on an immense sewage farm of some 2800 acres. He made some bold changes: he stopped the use of chemicals, sold off a large number of the cows and struck out on new lines generally. He is now treating the sewage of Birmingham and vicinity by a process or succession of processes that render the works, I think, the most elaborate and costly in the world.* The sewage is received in large tanks which are divided into sections so that the first and smaller section serves as a grit chamber. The deposit of sand is removed from the grit chamber by a dredge. The liquid flows on into another chamber, which is operated more as an ordinary settling tank or reservoir. From this settling chamber the sewage goes to the septic tanks. From the septic tanks the sewage flows some five miles to Dortmund tanks. The Dortmund tanks, as some of you probably know, were named from a place in Germany. They are circular tanks with conical shaped bottoms like those used at the Columbian Exposition, in 1893. The Dortmund tanks take out some of the large amount of suspended matter that comes through the septic tanks. From the Dortmund tanks the sewage goes to two different sets of beds; that is, part of it goes to a group of percolating filters with revolving arms, and part to another group of percolating filters with fixed distributors.

At the time of my visit (March, 1904) portions of the works were in progress of construction, and not all the sewage was treated by the combined processes which I have outlined; but the Dortmund tanks were under construction, and some of each of the two sets of percolating filters were being built. There were three or four different percolating filters making use of different materials and having different distributors.

The percolating filters with revolving sprinklers, at Birmingham, are composed of large pieces, some of coke, some of gravel

* I mean, of course, unit cost and not total cost.

and some of stone. Beginning at the bottom, the pieces of material are perhaps as large as one's head, after which they diminish in size. The filtering material in some of these filters is laid up to form its own enclosing walls, to a height of 7 feet. The filters are circular, and the sewage is admitted through a central pipe to a revolving distributor. Three or four different kinds of revolving distributors were in use at Birmingham, but the most likely ones were apparently those with radial arms, perforated, operating on the reaction principle, something like a revolving lawn sprinkler, and distributing sewage over the beds in small streams or drops.* There is a very elaborate distributor or revolving sprinkler on one of these beds, which might be called a series of revolving weirs; that is, there is a long iron or steel trough divided into sections so the sewage is distributed in thin sheets over weirs placed end to end. To keep the weirs level the inventor provided a big truss, supported on a pivot at the center and running on wheels, and a track at the outer end. A motor mounted on the wheels drives the device. I will not undertake to tell the cost of the distributing apparatus, but it runs up into the hundreds of pounds. Mr. Watson says this is the most perfect distributor yet evolved, but that it is so expensive as to be impracticable.

At the other percolating filters in Birmingham the sewage is distributed by means of fixed pipes, fitted with spray nozzles.

All the percolating filters have open drains at the bottom, so the sewage can pass through continuously and not be held up, as it is in the contact beds. The percolating filters are in some respects like our intermittent filters, except that they are composed of much coarser material and have a very open drainage system.

At Birmingham an expensive system of floors and underdrains is being used for some of the filters. All the filters have heavy concrete floors beneath them, and the underdrainage system of some of the filters is composed of continuous drain tiles (patented), set as close together as they can be placed. I should say, offhand, that the cost of the drain tiles, or certainly the drain tiles combined with the concrete floor on which they are placed, would exceed the cost per acre of our American intermittent filters; but the percolating filters treat the sewage at a vastly higher rate than do intermittent filters.

* In some places the sprinklers are operated intermittently and in others continuously. Where started and stopped alternately the sprinklers are sometimes called by the awkward name, intermittent continuous filters, but it seemed to me the concensus of practice in England was tending toward using the term percolating filters instead of intermittent continuous or trickling filters.

This elaborate combination at Birmingham is going to involve a large capital outlay, and we shall have to await figures for both construction and operation before knowing whether the saving in operating expense will warrant such high initial cost. Mr. Watson is certainly a very able and courageous man. He has revolutionized the sewage works of Birmingham, and to men accustomed to the uncertain tenure of office in American municipalities it is interesting to hear Mr. Watson talk as if he expected to stay there ten or fifteen years and carry out his plans for this plant, which is being constructed very slowly, indeed.

Mr. T. Howard Barnes.—What rate do they expect to obtain in the percolating filters?

Mr. Baker.—They expect rates running up to 1,200,000 U. S. gallons per acre per day. At other places in Great Britain much higher rates are claimed; as high as and sometimes double or treble the usual rates for slow sand water filtration, where there is no organic matter to deal with. But they are not attempting bacterial filtration; they are attempting to make a non-putrescible effluent.

Mr. Freeman C. Coffin.—Will the final results be that they will gain in this regard at Birmingham, or will there be more expense than by the old way?

Mr. Baker.—When you come to take interest on the plant and sinking fund and the heavy capital charges into account, it seems to me very questionable whether they will show a net saving. They will still have a large part of their 2800 acres of land for the reception of sewage and sludge.

Mr. Coffin.—Do they expect to get better results?

Mr. Baker.—They expect better results, and of course the population of the district is rapidly increasing. It is expected that the new Birmingham water supply which was introduced this summer will raise the water consumption. Besides, at the time I was in Birmingham they were using thousands of pan and pail closets, which will gradually be replaced by water closets, and still further increase the water consumption. In all that section of England, thousands and thousands of pan and pail closets are still in use, and in some places where they do have water closets, they catch the waste water from the sinks and store it up in tip-tanks, to flush out the water closets, or waste-water closets, as they are called.

At Salisbury the sewage works are combined with the refuse destructor. This practice is getting to be quite common in England, and is a very interesting development. The refuse is brought to

these refuse destructors and burned, and the heat generated by the burning of the refuse is used to raise the steam, and the steam is used to pump the sewage, and the clinker from the refuse destructor is used for the so-called bacteria beds.

Salisbury first proposed to depend wholly upon the septic tanks, followed by percolating filters, but it was compelled by the Local Government Board to add secondary filters. At Salisbury, fixed distributors are used for the percolating filters, consisting of corrugated iron sheets specially molded with very sharp angles, with notches cut through the higher angle and lower angle, and with nails inserted in the lower rows of holes. The idea is that the sewage will trickle down and drop off the nails and also drop through the upper notches and thus be evenly distributed. Mr. F. Wallis Stoddard, of Bristol, is very enthusiastic over this method of distribution, which was devised by him. He claims that contact beds are utterly wrong, and that with his system of percolating filters he can get rates as high as 6,000,000 to 8,000,000 U. S. gallons per acre per day.

Mr. Coffin.—Does the septic tank take out enough of the solid matter to prevent clogging of the different sprinkling arrangements?

Mr. Baker.—No, the care-takers have to give the sprinklers attention. The perforations in the tubes, I was told at one of the works, have to be kept open by swabbing them out. Obviously such sprinklers would not work with the thermometer down to 30 or 40° F. below zero.

At Exeter, Yeovil and Barrhead they have septic tanks and contact beds installed by the Septic Tank Syndicate. The small Exeter tank, as is generally known, was the first to be built by Mr. Donald Cameron. The Local Government Board insisted that the large septic tanks and contact beds should be supplemented by land treatment, so an area of land was provided and the sewage is going over this land; but the land treatment seems to be carried on in a perfunctory manner. The authorities were not required to underdrain the land, and the method of distribution which I saw permitted a great deal of the effluent to find its way through the ditches into the river, without much land treatment.

At Yeovil, an insolating pool, also called an aërating pool, was provided. It is a large shallow tank, filled in at the bottom with broken stone. The effluent from the first contact bed comes down into and flows slowly across the pool. The idea was that the sun and air would aid the process very materially. But they still had to provide land for the treatment of the contact bed effluent.

The borough surveyor went with me to the septic tanks at Yeovil and had all the manhole covers taken off. He found the septic tanks nearly filled with sludge. In some places the sludge came nearly up to the surface of the sewage, but when we got down to the outlet end, much less sludge was found. It is only fair to say that the surveyor had been ill, and meanwhile the works had apparently been neglected. The Yeovil sewage is difficult to deal with, as it contains much refuse from leather manufactories, with many pieces of leather in it.

At Manchester, the engineering work is more like American practice than what I saw elsewhere. Dr. Gilbert J. Fowler is both superintendent and chemist of the sewage works,* and the designing engineer associated with him is Mr. J. P. Wilkinson, Assoc. M. Inst. C. E., of Manchester. They are putting in a far less expensive construction than at most of the British works, and are abandoning chemical precipitation, as fast as possible, for septic tanks and single contact beds. They propose, if they are compelled to, to build secondary contact beds, and they also have land in reserve, which can be utilized for broad irrigation. In addition there is a large area of special filter beds for storm-water, and instead of letting those storm-water beds remain idle between storms a certain amount of sewage is applied at frequent intervals to keep the beds in good bacterial condition.

At Salford, I saw chemical precipitation tanks, roughing filters and percolating filters. Here Mr. Joseph Corbett, the borough engineer, has one bed $5\frac{1}{2}$ acres in size, entirely undivided by partitions. He has a system of cast-iron distributing pipes laid at frequent intervals and set with nozzles, so that when he turns on the sewage he gets a multiplicity of nozzle sprays, and sprinkles the sewage over these beds.

At Chadderton, I found in the chemical precipitation tanks an arrangement for removing the sludge without drawing off the sewage, consisting of perforated pipes moved by means of overhead wheels. A rubber squeegee is placed behind and immediately below the pipe so that the perforated pipe is moved along the bottom of the tank and the squeegee pushes the sludge forward. On opening a gate or valve the head of the sewage forces the sludge through the perforated pipe by gravity. The manager said the device worked satisfactorily. A similar device is used elsewhere in circular chemi-

* Dr. Fowler has recently been appointed consulting chemist to the Manchester works in order that he may devote himself chiefly to private practice.

cal precipitation tanks. In such cases the perforated pipe swings radially inside.

Chadderton is an illustration of how numerous sewage works are in Great Britain. I stumbled upon it when I was hunting for another plant. The manager said that so long as I was there I had better see his works, and when I got through looking it over, all I had to do was to jump over the fence and I was on the grounds of the one for which I was searching.

These were the Oldham works, consisting of sedimentation tanks and contact beds. The settled sewage is distributed on the contact beds by wooden troughs. Wooden troughs for distributing sewage are more common in England than I should have expected.

The sludge at Oldham contains a large amount of grease; and Mr. A. H. Valentine, the chemist of the works, who was formerly an assistant of Dr. Fowler, at Manchester, is trying to have the sewage committee put in the necessary plant for recovering the grease. There is one day of the week that it is particularly heavy, and he found, on inquiry, that the reason of that was that everyone ate tripe the day before.

At Accrington and Church, one of the earliest systems of revolving sprinklers was put in use, first known as the Whittaker, and afterward the Whittaker & Bryant, and then the Candy-Whittaker. The London company now promoting this sprinkler has the high-sounding name, The Patent Automatic Sewage Distributors, Limited. At Accrington, as well as at some other places having percolating filters, sedimentation tanks are provided to remove the large amount of matter that goes through percolating filters.

Mr. Barnes.—May I ask Mr. Baker how large the settling tanks are?

Mr. Baker.—Very small, indeed, not enough to serve for more than probably an hour or two hours' flow.

At Burnley, I found one of the best managed plants that I saw. The material from the contact beds (called mill ashes or furnace ashes, really cinders from factory furnaces) was being taken out, washed and replaced. Some new material was also being placed in one of the beds, and I was astonished to find that it was so very soft that I could punch it to pieces with my umbrella. It is surprising that in so many English plants, material should be used that breaks down so easily.

Glasgow was particularly interesting, because notwithstanding all the fervor with which people in Great Britain are adopting the bacterial processes, this city is constructing several new chemical precipitation plants, and this after having made some experiments

on the newer processes. Mr. A. B. MacDonald, the city engineer of Glasgow, is very confident that he can get all the purification that is needed from chemical precipitation, and that it will be very much cheaper, and that the other people in Great Britain will find that they have made a mistake in being in such a hurry to take up with some of the new processes. He is putting in some fine plants. He has built two elevated cast-iron tanks, each of 1500 long tons capacity, for the storage of the sludge. Sludge storage tanks are in use in London also; and in London, as well as in Glasgow, the sludge is loaded on steamers and finally dumped in salt water.

PROF. L. P. KINNICUTT.—Do they dry much of their sludge? They claimed five years ago that they could dry it.

MR. BAKER.—I think they have given that up.*

At York, Mr. Creer, city engineer, has put in what he calls experimental filters, but they are really on a working scale; they are of the percolating sort. He has made some extensive studies and has read some interesting papers before the British societies, giving the results that he has obtained. He has made some modifications, and, if I remember rightly, he has adopted the name "York filter."

At Leeds, chemical precipitation is still employed, but there, as I have stated elsewhere, may be seen a veritable museum of experimental plants. About everything that anyone could conceive of as a possible means of treating sewage has been tried, and new methods are being tested as they come along. Unfortunately for others, at least, the council has stopped publishing the results of its investigations. After making an elaborate report, in 1900, it concluded to utilize some land bought for a sewage farm. The opposition to the farm pointed to the reports on the experiments as proof that the newer processes were very efficacious. The authorities were sorry that they had published the reports, and discontinued them. Since I was at Leeds, engineers have advised the use of three pipes about 47 inches in diameter to convey the sewage to proposed new works, owing largely to the fact that the outfall sewers would pass over some coal land which is pretty badly undermined, making it desirable to keep the weight of the conduits down to the lowest figure possible.

The large sewage farm of 1950 acres, at Nottingham, and its managers are particularly interesting, since Mr. Arthur A. Avis, the present manager, has been some eight years in charge of the

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* In revising my remarks I find by reference to my notes that some of the sludge is passed through a Cummer (American) dryer, then screened, ground to powder, and sold under the name of "Globe Fertilizer."

farm, and, before that, was for ten years assistant to his father. Mr. Avis, Sr., laid out the works about 1879, and continued as manager until his death, in 1897. That is an instance of the way municipal works are conducted in Great Britain.

At Salisbury, the city surveyor, who had been in office for some years, told me that he had succeeded his father, and I learned subsequently that his father was city surveyor for fifty years. At several refuse destructors and sewage works I took pains to find out how many years the manager had been in charge, and often it was surprising how long he had been in office. If the works had not been long in use, then the chances were that these men had been previously engaged by the city in some other capacity. Periods of service varying from twenty-five to thirty years are quite common. The hardest thing that I had to try to explain in Great Britain was why we changed our municipal officials so often. They said, "Why, I should not think it would work well; I should not think you would get good results." I said, "We do not." They wanted to know why we continued to change, and I tried to explain why, but I could not make them understand.

At Leicester, which is nearly the last place on my list, sewage is pumped 180 feet and then disposed of on the densest clay soil that can be imagined. The land was underdrained for farming purposes before it was taken over as a sewage farm. The purification effected is so poor that it is necessary to pick up the sewage by a system of intercepting sewers and spread it over the land a second time. There is an arrangement by which it can be applied a third time when necessary. This is another example of what good engineering will do. Mr. E. George Mawbey, M. Inst. C. E., has contended against these great odds, and got along very well, indeed; but he has done it by close attention to details and by turning over the soil repeatedly. Compared with others, he does not go much into dairying and raising crops. Some experiments have been made at Leicester, and it is proposed to enlarge the small settling tanks put in single contact beds, and continue to apply the sewage to land.

The last plant I visited was at Hampton, and there I found a so-called hydrolytic tank in process of construction. It was one of the most interesting things I saw. The original works were built in accordance with the ideas of Mr. Dibdin, in the early days of contact beds. He put in triple contact beds, but they were found insufficient as the sewage and population increased. Recently Mr. Shone and his partner, Mr. Ault, as engineers, have been advising and co-operating with Dr. W. Owen Travis, of Hampton, in the

perfection of the so-called hydrolytic tank, which is the idea of the latter. To state briefly the character of that tank: The sewage enters two side compartments and a central compartment of the tank. The side compartments have sloping false bottoms perforated with slots at the acute angle at the bottom, so that the sludge will pass down through the slots into the central compartment; 90 per cent. of sewage goes into the side compartments and 10 per cent. goes into the central compartment. The theory is that it is not necessary for sewage to remain a long time in a septic tank; that if the sludge can only be retained the larger volume of sewage may be allowed to pass out. I was particularly interested in this, because in the early days of the septic tank I made known some of my ideas on that subject and stated that it seemed to me unnecessary to retain the sewage more than a few hours. In Great Britain it is retained say twenty-four hours.

As has been stated, the only basis of classification of the processes in use at the various works visited has seemed to be the final treatment employed. Even this has to be modified for a few works, such as Exeter and Yeovil, where, to satisfy rulings of the Local Government Board in the earlier days of septic tanks and contact beds, supplementary land was provided. Of the twenty-four works visited, five employ sewage farming, three chemical precipitation, eleven contact beds and five percolating filters for final treatment. The five sewage farms and the three chemical precipitation plants are the sole as well as the final methods of treatment, except for grit chambers at two of the farms and small settling reservoirs, really grit chambers, at another farm. Leicester proposes preliminary treatment by settling tanks and single contact beds at its sewage farm. London contemplates abandoning chemical precipitation for septic tanks, aëration and single contact beds. Leeds has been experimenting for years with the idea of substituting some of the newer processes for chemical precipitation. The eleven works with contact beds and the five with percolating filters are not, in every case, treating all their sewage by those methods. In some instances, the works are gradually being converted to one or the other method, and in some the two methods are being used side by side.

The preliminary treatment at the majority of the sixteen combined works is affected by septic tanks, nearly all of which are open. In a number of cases, however, either sedimentation or chemical precipitation is in use, and while this is only temporary, in some instances, in others it is proposed to continue one of those processes.

The foregoing summary of the methods in use at the works

visited appears to remove much of the previously mentioned confusion as to British practice. It will be observed, however, that it does so by eliminating details. Going a step further in the latter direction, and leaving specific works out of consideration, the general status of sewage treatment in Great Britain may be summarized as follows:

Of the older processes of sewage treatment, chemical precipitation and broad irrigation are still widely practiced, with a strong but by no means universal tendency to abandon the former, and also with a notable clinging to broad irrigation where suitable land for the purpose is available. Plain sedimentation is in use in more places than one might suppose, and it would not be surprising to see it grow in favor, particularly as a sequence to percolating filters. Intermittent filtration does not have the meaning abroad that it does in America. It is chiefly an adjunct of sewage farms, for use when either the growing crops or cold weather does not permit broad irrigation alone, and it is used here and there alongside of contact beds or quite independently of other final processes. For the most part, however, intermittent filtration in Great Britain is merely intensified land treatment for a year or so on particularly favorable sandy or gravelly areas.

Dr. Barwise, in the new edition of his "Purification of Sewage" (London and New York, 1904), states that the intermittent filtration area should be used for a year and then turned back into the sewage farm, and that it should then have seven years rest, so that the intermittent filtration area would be used only once in seven years. That shows how different it is from our understanding of intermittent filtration areas.

Of the newer processes of treatment, notwithstanding a multiplicity of names and of details of construction and operation, it may be said that they fall under three heads: (1) Septic tanks, (2) contact beds, (3) percolating filters. My impressions are that by far the larger number of the septic tanks are open, that no questions of patent rights have yet been brought into court where open tanks have been built, and that the closed septic tank is generally regarded as a patent monopoly.

There are many more contact beds than percolating filters, but that is at least partly accounted for by the fact that the contact bed is the older of the two. The percolating filters seem to be rapidly gaining in favor.

I have not touched upon questions of cost of construction and operation, amount of sludge produced or reduced by septic tanks and rates of treatment by means of contact beds and percolating

filters. This omission is largely due to a lack of suitable comparative data, and also largely to the fact that local conditions affect all these questions so materially as to make any statements likely to be misleading, unless accompanied by more qualifying data than can well be given here.

Before concluding, I wish to speak briefly of the contact and filtering materials used abroad, and of the relation of the Local Government Board to sewage works. Almost every imaginable contact and filtering material available has been tried either experimentally or in practice: coke, coal, cinders or clinkers, burned clay, broken pottery and brick, broken stone and gravel. Probably the material most commonly used is clinker, preferably that from refuse destructors. Gravel and broken stone have been seldom used on a working scale, largely because they are so expensive in most parts of Great Britain, but partly, it appears, because it is thought that there is more virtue in the other materials. Sand is too fine for either contact beds or percolating filters, and in most localities is not to be had at a low price. It seems probable that as the years go by the value of more permanent materials than either ordinary clinkers or coke will be realized, and that where well vitrified refuse destructor clinker cannot be obtained, gravel or broken stone will come into more general use.

Mr. Dibdin is now pushing slate as a material for contact beds; he has taken out patents on what he calls "Multiple Contact Beds," and he is using waste slate from quarries, laid flatwise, with slats to separate the pieces, and in that way getting a very large open space. He is claiming good results.

Of the Local Government Board I will only say that as a rule permanent loans for sewage works in England must be approved by it before the works can be built, or else the loans must be sanctioned by Parliament. The latter appears to be too expensive for any but the larger municipalities, and does not seem to be often employed by them. This power of the Local Government Board gives it virtual control over sewage treatment in Great Britain, down to small details, if it chooses. Much dissatisfaction over the conservatism of the board was felt when the septic tank and the contact bed first came to the front, and no little grumbling is still heard in some quarters. The board, however, is less strict than formerly about the provision of land for the treatment of sewage from the so-called bacterial processes, but it has not yet come to what is generally considered a rational view as to the treatment of storm-water. Its old rule was to require works of sufficient capacity for the full treatment of storm-water up to three times the dry weather

flow, and special works for treating the excess up to a total of six times that quantity. In other words, where the dry weather flow is 1,000,000 gallons a day, septic tanks and contact beds, for instance, must be able to deal with 3,000,000 gallons a day and storm-water beds with 3,000,000 additional. Most sewerage systems in England, it may be added, are on the combined plan.

The Local Government Board conducts no experimental work, but has a staff of so-called engineering and medical inspectors, members of which are detailed to hold hearings on applications for loans. The tendency of the board, as might be expected, is wholly conservative. The need of a central general investigation of methods of sewage treatment was felt some years ago, and, as a result, a new Royal Commission on Sewage Disposal was appointed. The commission has been making some extended studies of various methods of treatment, largely of works in operation, and has issued several preliminary reports. All eyes are turned to the final report of the commission, which is expected soon. It is hoped that this report will do much toward making less onerous and more rational the requirements of the Local Government Board, and that it will materially aid in lessening the confusion now caused by the many rival methods, or, more properly, modifications of methods, of sewage treatment in Great Britain.

DISCUSSION.

The Chairman.—The Massachusetts State Board of Health, as we all know, has done valuable work in experimenting on sewage disposal. Mr. H. W. Clark, the chemist of the Board, has had charge of the work and perhaps he would discuss the matter. We should be glad to hear from him.

Mr. H. W. Clark.—Mr. President, I do not wish to discuss here the English filters for sewage disposal, because I know nothing about them, except what I have read. I thought, however, it would be of interest to bring down here to-night some samples of effluent from filters of a somewhat similar kind which we have in operation at Lawrence.

I have here four effluents; one from an intermittent sand filter, two from trickling, or percolating filters, or, to use the usual title that I have given them, "intermittent continuous filters," and one from a contact filter.

In the first place, I have an effluent from an intermittent sand filter put in operation fourteen years ago, and which is constructed of five feet in depth of sand. This effluent was collected about two

weeks ago. This filter and its results have been written about so fully in the reports that there is little to be said about it here. However, I wished to show a sample of the effluent that you might see its fine appearance.

I have here, also, the effluents of two intermittent continuous filters, one operating at Lawrence and one at Andover. The Lawrence filter is constructed of cinders, and the Andover filter of broken stone. The sample from the filter at Andover is contained in bottle No. 222. This filter is constructed of about 76 inches in depth of broken stone, the stone varying in size from stone 8 or 10 inches in diameter at the bottom of the filter to stone 1 or $1\frac{1}{4}$ inches in diameter at the top. The filter is 17 feet 4 inches in diameter, and sewage is distributed over it by means of an automatic V-shaped tipping basin into which the sewage flows. This filter operates at the rate of 1,500,000 gallons per acre daily. It was put into operation more than a year ago, and through last winter the sewage was applied below the surface of the filter by means of small galvanized iron channels over the edge of which the sewage flowed; that is, during the winter we did away with the tipping basin. As you know, last winter was a very cold one, and these channels were only a slight distance below the surface, yet this filter worked beautifully throughout the entire winter. The temperature of the sewage as it passed to the filter was about 50° F., although it comes through about two miles of pipe from the village of Andover. The sewage lost only two or three degrees of heat in passing through the filter.

The effluent at the present time, as shown in this bottle, contains a great deal of suspended matter, but this suspended matter settles out very readily. The nitrates in this sample were 2.77 parts per 100,000, and it is non-putrescible. I am perfectly willing to have the paper cap taken off, in order that you may see how little odor the sample has.

I have also here the effluent of another intermittent continuous filter, which is less than six feet deep and constructed of cinders. It operates at the rate of 1,000,000 gallons per acre daily. This effluent contains more sediment than the other, but this sediment also settles out in a very short time. This sample is also non-putrescible.

In a third bottle I have an effluent of a coke contact filter, about five feet in depth, and operated at the rate of 550,000 gallons per acre daily. The nitrates are practically absent from this sample, yet nitrates have been formed while sewage was passing through the

filter, but afterward reduced, the oxygen of the nitrates being used to further oxidize organic matter.

In regard to matter in suspension in this effluent; you know if sewage has 30 or 40 parts per 100,000 of matter in suspension, it means that the sewage contains about 1 pound of dry matter in every 350 gallons of sewage. The matter in suspension in the effluents that I have here is very much less in amount and its nature is quite different from that of the sewage matter. If you take the sediment from Lawrence sewage and dry it, this sediment will lose perhaps 60 per cent. on ignition, while the sediment from these filters will lose about 30 per cent. The sewage sediment will contain about 2½ per cent. of nitrogen by weight, while the sediment in the effluent will contain about one-half that amount. It has seemed in studying these effluents that some method of determining approximately and quickly the amount of matter in suspension would be of considerable value, and I have lately established at Lawrence a standard for reading the turbidity and sediment of the effluents of sewage filters, based upon the actual amount of matter of this nature in suspension in these effluents. In this standard, 0.01 of a gram of matter in suspension in a liter of water gives a reading of one part of turbidity, and by this standard the amount of matter actually in suspension in the effluent of various kinds of sewage filters can be determined much more accurately than by any other turbidity standard that can be used in laboratory work in the examination of such waters. Since the first of June of the present year, this standard has been used at Lawrence, and in the report of the experiment station for 1904, the turbidity and sediment of the effluents examined there will be given in the terms of this standard.

Mr. Barnes.—Are there any nitrates in the effluent from the six-foot filter?

Mr. Clark.—Yes, it is marked on the bottle, 1.33 parts.

Mr. Fuller.—I understand you distributed the sewage below the surface in one instance?

Mr. Clark.—During last winter we did.

Mr. Fuller.—How far below?

Mr. Clark.—I think it was six inches below; I am not quite positive, however, in regard to this. I think that in spite of low temperature we could have kept it nearer the surface, because we had such a coating of snow over the filter.

Mr. Fuller.—Do you know whether it filled the entire superficial area?

Mr. Clark.—Of course we don't know that, but we know it filled a good portion, or we should not have obtained the results we did.

Mr. Fuller.—Could you continue to distribute it that way without having difficulty with the iron pipes?

Mr. Clark.—I could not answer that. I think in the course of time we should have to attend to them. I would say, however, that we have deeper percolating than I have mentioned. We have filters ten feet in depth operating at the rate of 2,000,000 gallons per acre daily, and the filters have been operating four or five years and are still open, showing no more clogging than they did soon after beginning operation.

Prof. Leonard P. Kinnicutt.—It is now two years since I last had the pleasure of studying the various English plants for the disposal of sewage, but I feel, after listening to Mr. Baker, that the next best thing to seeing for myself the work that has been done since that time is to see it through Mr. Baker's eyes.

The clear and interesting account that he has given us of his visit to England shows, I think, first of all, the conscientious work that is being done in trying to solve the question of sewage disposal, and I believe, also, it is not an indication of failure or lack of progress that we see in England so many different experiments and methods being tried, but only a sign that we are rapidly learning that different methods are required to meet different local conditions. The serious problem at the present time is not whether sewage can be satisfactorily treated, but what method of treatment is best adapted to meet all the requirements of a particular locality, including the character of the sewage.

The London sewage plant is most impressive, if for no other reason than from the volume of sewage that comes to the plant each day, and it is a plant where not only very much can be learned regarding the treatment of sewage with chemicals, but also as to the seriousness of the problem of treating 200,000,000 gallons per day by bacterial methods. The careful experiments of Professor Frank Clowes, given to us in his reports on the "Bacterial Treatment of London Crude Sewage," show the possibility of treating London sewage otherwise than by chemicals, yet the undertaking is one not to be entered upon lightly, and as Mr. Baker has said, it will probably be many years before bacterial treatment will be substituted for the present method.

Sewage farming finds its strongest advocate in Colonel Jones, and I believe there are certain conditions, unfortunately occurring only too seldom, when this method can be successfully applied. We have, however, traveled far since the day when this method was thought to be a panacea for all our troubles, but that day is vividly recalled to mind when one sees at Barking the beginning of a

tunnel which was to carry the sewage of London far away into the country to be sold, I know not at what price per thousand gallons, to fertilize the soil.

Birmingham, Mr. Baker tells us, is at the present time one of the most interesting of all English cities for those who wish to study the modern bacterial methods of sewage treatment, and in this I most thoroughly agree, for at Saltley, a few miles from Birmingham, are the disposal works of the Birmingham, Tame and Rea District, under the direct charge of Mr. John Duncan Watson, one of the most thoughtful and capable of England's sanitary engineers, who has, during the past four years, not only radically changed the method of treatment of the sewage of this district, the mean dry weather flow averaging 22,000,000 gallons per day, but has also been making experiments on the bacterial treatment of sewage, on a scale which makes much of the experimental work done elsewhere seem Lilliputian in comparison.

From 1872 to February, 1901, the method of sewage treatment at Saltley consisted of chemical precipitation followed by broad irrigation. The chemical treatment consisted of adding milk of lime, 12 grains of lime to the imperial gallon, and passing the sewage through sedimentation tanks. The amount of sewage thus treated between 1890 and 1900 averaged about 20,000,000 gallons per day, and the volume of liquid sludge, containing 90 per cent. of water, equalling about 260,000 cubic yards, was disposed of by trenching it into the soil. The amount of land owned by the Drainage Board up to 1882 was only 272 acres; this amount has been gradually increased till the area at the present time amounts to 2830 acres, of which 1780 acres are used for broad irrigation, the number of persons served per acre being 451.

In 1901, under the advice of Mr. Watson, the above system was radically changed, the addition of lime to the sewage was suspended, and the deposition tanks began to be used for septic action. As a result there was a saving of $15,000 to $20,000 a year for lime, and a reduction of 25 per cent. in the amount of sludge formed and not a deterioration, as some had feared, of the effluent from the subsequent land treatment, broad irrigation, but a gradual improvement. Not content with the advance thus made, Mr. Watson began experiments on bacterial treatment, using $\frac{1}{4}$-acre areas, and planned a very large addition to the plant, which is now approaching completion. This addition is situated in the district of the borough of Sutton-Coldfield, about five miles from the outfall sewer at Saltley, and the effluent from the septic tanks at that place is brought in a conduit of some six million imperial gallons

capacity, allowing of some considerable saving of septic tank capacity at Saltley. The sewage from the conduit enters an intake chamber, in which there is an apparatus regulating automatically the flow of the sewage into Dortmund tanks. These are five in number, and serve to remove the suspended matter in the effluent from the septic tanks. These tanks, according to a private communication received this week, "Arrest more than 70 per cent. of the matter in suspension in the septic sewage, so that the septic effluent that is run upon the primary percolating beds is as free from suspended matter as there is any practical need for." There are five of these primary percolating experimental beds, four of which are circular, each having an area of one-fourth acre, and one is rectangular, of one-half acre area, and different methods of spraying the sewage are used on the different beds. From these percolating beds the effluent runs to a sedimentation basin, to arrest the humus which is always found in effluents from percolating filters. An installation of four secondary experimental percolating beds, each an acre in area, is now being constructed, so that if desired the effluent from the sedimentation tank can be run upon these beds instead of upon the land.

Percolating filters, as we all know, are the most modern of the various bacterial methods, and were first tried, if I am not mistaken, at Accrington, under the direction of Colonel Whitaker, and the percolating filter has often been called the Whitaker filter, and there seems to be no question that in this way a greater amount of sewage can be treated per acre than by any other method. The construction of these filters is not necessarily very costly, nor their maintenance, when taken into consideration with the amount of sewage treated, though they require rather constant attention and supervision. I think Mr. Baker will agree with me when I say that this method should receive careful consideration from American engineers.

Possibly I cannot better close these few remarks than by calling to your attention the two following tables which are given in Mr. Watson's most excellent lecture on "The Purification of Sewage," delivered at the University of Birmingham, in February, 1903, which, as far as I know, cannot be obtained in this country in printed form.

Table Showing Quantity of Sewage Purified by Means of Contact Beds in 24 Hours per Acre of Bed, with Average Percentage of Purification on Crude Sewage.

Name of Town or District.	Time During Which the Beds Were at Work.	Depth of Bed.	Quantity of Sewage Treated in 24 Hours per Acre of Bed.	Average Percentage of Purification.	
				Oxygen Absorbed.	Albuminoid Ammonia.
	Years.	Feet.	Imp. Galls.	Per cent.	Per cent.
Single Contact:					
Croydon	2	3.75	635,625	63.8	60.7
Manchester . . .	4.5	3.33	459,000	75	70
*Birmingham . . .	1	4.5	500,000	80	79
Double Contact:					
Blackburn	2	5.5	600,000	75 to 80	97.1
Burnley	5	3	193,000	87.0	84.8
Carlisle	2	4	905,700	71.0	61.0
Leeds	2	5 and 6	500,000	95	90
Sheffield	3	5	1,000,000	87 to 90	92
"	3	3.33	650,000		

* Note.—This result is obtained from averaging three different single contact beds, as follows:

	Oxygen Absorbed.	Albuminoid Ammonia.
Coal	94.6	85
Clinker	75.5	82
Slag	70	70

Table Showing Quantity of Sewage Purified by Means of Percolation Bacteria Beds at Various Places in 24 Hours per Acre of Bed, with Average Percentage of Purification on Crude Sewage.

Name of Town or District.	Time During Which the Beds Were at Work.	Depth of Bed.	Quantity of Sewage Treated in 24 Hours per Acre of Bed.	Average Percentage of Purification.	
				Oxygen Absorbed.	Albuminoid Ammonia.
	Years.	Feet.	Imp. Galls.	Per cent.	Per cent.
Leeds.	3½	9	1,000,000	95.0	90.0
Accrington	3	8 to 9	1,936,000	90.0	91.3
Birmingham	½	5	1,000,000	86.3	88.4
Hyde	3	9	2,178,000	85.7	90.0
York	1	6.5	2,129,600	84.5	90.0
Rochdale	2½	9	1,936,000	84.0	84.2

The Chairman.—We have with us a member of the Connecticut State Board of Health, Mr. T. H. McKenzie, and we should be very glad to hear from him, if he has a word to say.

Mr. T. H. McKenzie.—Mr. Chairman and gentlemen: I had no thought of being heard, but I would like to ask Mr. Baker, with reference to the septic tanks he found in use in England, as to whether there were objectionable odors from those tanks, or odors which were noticeable at any distance, and whether or not the effluent of those tanks was turned into the stream without any subsequent treatment.

Mr. Baker.—In no case that I saw was the effluent turned into a stream without further treatment, and I did not notice bad odors from septic tanks or from any sewage works of any kind that I visited.

Mr. McKenzie.—I mean the uncovered tanks.

Mr. Baker.—Yes. I began my visits in March, and most of them were made in March and April, before the weather had become warm. In warmer weather it might have been otherwise.

Mr. McKenzie.—I suppose the sewage freezes in the tanks in winter.

Mr. Baker.—Freezing does not seem to be considered. I was told in London that the ground was not frozen once all last winter. Farther north perhaps it would freeze.

Mr. McKenzie.—And you found the general practice there was that the sewage remained in the tanks twenty-four hours under septic treatment?

Mr. Baker.—I should say the general practice was to allow it to remain from twenty to twenty-four hours, but as I stated in the paper, one should be very cautious in making statements relating to sewage works practice, because with everything in such a transitory stage it is hardly fair to go into much detail.

Mr. McKenzie.—I think you said you found that the Local Government Board approved of septic tanks?

Mr. Baker.—The matter is almost wholly under the control of the Local Government Board, and it is approving septic tanks, provided they are followed by other processes—final processes of treatment. Inland, I do not suppose the Local Government Board would approve the septic tank as the sole means of treatment. In a seaside town it might. There are comparatively few seaside towns treating the sewage, except by screens, or some such rough and ready means.

Mr. McKenzie.—I understand you did not find that intermittent filtration was much in use either through natural soil or through artificially constructed beds.

Mr. Baker.—The intermittent filters there are mostly selected areas of sewage farms, chosen because they happen to contain a little sand, or a little better sand, or a little gravel, and such areas are used to ease up on the farms.

Mr. McKenzie.—I am not prepared to discuss the subject to-night, as I did not know that I was to be called upon.

The Chairman.—We are very glad to hear from you. Are there any other questions to be asked?

Prof. Kinnicutt. Did you see any plowing of coal into the soil for intermittent filters?

Mr. Baker.—I did not see anything like that, but I saw sludge being trenched in at Birmingham.

ISTHMUS CANAL: SEA LEVEL VERSUS LOCKS.

By William W. Redfield, Member of the Engineers' Club of Minneapolis.

[Read before the Club, April 20, 1903.*]

To make this paper as brief as possible, I will refer to a previous paper of mine, upon the same subject as this paper is to treat of; said paper appeared in the Journal of the Association of Engineering Societies of May, 1900, Vol. 24, No. 5 and page 207. In that article there was a thorough ventilation of the arguments, *pro* and *con*, in reference to the three routes of Nicaragua, Panama and San Blas.

The author is still, as he was then, totally in favor of the San Blas route, and for full, detailed information in regard thereto he respectfully refers all inquirers to the aforesaid article.

The question then naturally arises: Why was the San Blas route not chosen? and why was the Panama route selected and negotiations therefor initiated? Was it because the Panama route was found, on inspection, to be a more feasible route, from an engineering point of view, than the other two? Not at all. Reasons of state, etc., rendered it apparently necessary to select the Panama route, in order to secure a right for *any* canal whatever across Colombia.

If the original plan for a sea-level canal at Panama had been adhered to, the difficulties hereinafter mentioned would undoubtedly have forced a change of route to that of San Blas. But the lock system was subsequently adopted by the French Company and considerable work was performed upon the canal. The Panama Railroad was adjacent to the canal route. The concessions granted by the Colombian Government to the French Company had to be transferred to the United States and sufficient treaty rights acquired by our Government from Colombia. This, in a measure, committed the Government to the Panama route and at least seemed to require an initiative upon that basis.

But it does not necessarily follow, that cool, sober second thought should not ultimately prevail; nor does it act against the idea of securing a strip of territory across Colombia, in width 50 to 60 miles, extending west of the Panama route and east of the San Blas route, on which to locate suitably the right canal. Then would naturally follow an exhaustive topographical survey of said entire area, thereby ensuring, beyond doubt, the best route in every respect,

* Manuscript received December 15, 1904.—Secretary, Ass'n of Eng. Socs.

and work could be commenced on the canal with confidence that no mistake was being made.

Now, if the present arrangements are carried out, what follows? A canal, if no serious drawbacks occur, would be built on the lock system, having a summit level of 125 feet above mean sea level, and with a summit reach of about 21 miles in length. The *Review of Reviews* for January, 1902, says: "The Commission estimates that the work done on the Isthmus by the late French Company and the plant of the Panama Railroad itself would be worth about $34,000,000 to the United States, if our country were to acquire control of that route and execute the work according to the project approved of by the Commission."

That means that the United States would save an expense of $34,000,000 in completing the canal, which certainly is an advantage for the Panama route. That, however, as I will show, is *all*.

A dam to restrain and regulate the flow of the Chagres River will be necessary. This would cost many millions, and is absolutely essential in order to maintain the summit level constantly at the elevation of 125 feet above mean sea level. To all this must be added the cost of completing the unfinished portions of the canal itself and all the miscellaneous expenses, and the total cost will be enormous.

After the cost of construction comes the expense of maintenance and operation.

Being a canal with locks, such maintenance must be incessant and especially at the Chagres River dam. The latter would be an uncertain quantity and would be a constant menace, no matter how carefully constructed.

Now a few points may properly be brought forward in reference to the San Blas route. This route is located about 30 to 50 miles east of the Panama route; is 29 $\frac{17}{100}$ miles long; has a summit ridge of 1142 feet above mean sea level. But only for seven miles is the surface of the ground above 300 feet; for about five miles it is between 300 feet and 80 feet above mean sea level, and the balance of the length is less; ten miles is of exceedingly light construction. Or, instead of canal proper, a tidewater stream could be improved and utilized for canal purposes.

The entire line is straight from end to end; is a sea-level route, requiring only a tidal lock at each end; has no expensive dam or locks to constantly protect, maintain and operate.

The high ridge of 1142 feet elevation may stagger many, and the question may well be asked: Why was the Panama route originally on a sea-level basis, and having a summit ridge of only

some 400 feet in elevation, afterward changed to a lock system canal? Was it because by deducting 125 feet from 400 feet made it less difficult to pass the summit ridge? No. If the 400 feet of ridge had been *all* that stood in the way, the French Company would have had a sea-level canal completed and in successful service to-day.

The reason consists not in the *height alone* of the ridge. If that had been all, a few hundred, or even thousand, feet more in height would have delayed the completion a few months longer. The essential difficulty is due to the disastrous floods of the Chagres River and, in a lesser degree, to those of the Rio Grande River, along whose valleys the routes of both Panama Railroad and canal had been located.

Right here, attention is called to a scientific distinction that should be borne in mind between locating a railroad route or a canal route. A railroad is located essentially on the *surface* of the ground and may, in some cases, be exactly on the surface, or on an embankment entirely; but a canal is always in excavation (excepting aqueducts for crossing of streams.) A railroad has ascending or descending grades on inclined planes; is practically located on the surface; is placed in the lowest pass over or through a ridge or divide, more for economizing simultaneously the cost of construction and of maintenance and operation when completed. If a railroad is built on a straight line and on a level grade, it will cost much to construct and to maintain, and little to operate. If the grades are made as heavy as the limit allowed, and the curvature be as sharp as the allowed limit, and the lowest pass be made use of, the first cost would be reduced; the cost of maintenance might possibly be also reduced, but the cost of operation would be materially increased.

First cost is a quantity used only once; maintenance and operation are quantities that are repeated as long as the road exists. Therefore it is necessary in locating a railroad to average judiciously the following conditions: Shortest route; the lightest curves; easy grades; minimum quantity of material removed; and, as a rule, it is necessary to utilize the lowest passes for overcoming summits.

On a canal route, however, the conditions and requirements are wholly different; and *that* is the "rock upon which many have split."

An ideal canal route (irrespective of size of canal) requires an equalized combination of all or *most* of the following conditions: The shortest and straightest route; as few locks as possible (none

at all, if possible); good harbors at each end; economy of construction, considering duly the nature of soil, streams to be encountered, dams to be built, ease of handling and removing of material.

Now, with this as a general statement, to be specific—

The San Blas route has a great advantage, in spite of that 1142 feet in height, and seven miles of either tunnel or deep excavation. It is an anticlinal route; the Panama route is a synclinal route. The Panama route is synclinal because the waters flow toward the canal route and have to be taken care of.

The San Blas route is anticlinal, because the waters (and fortunately in a less volume) flow *away* from the canal route in *both* directions. What does this mean? It means less difficulty in excavating to sea level; it means a strong chance of drier material to be handled and removed. As to the choice of tunnel or open cut at the summit ridge, it must be admitted that in either case the quantity in cubic yards would be vastly greater than at Panama; but being in all probability drier than that at Panama, where even with the summit level at 125 feet above sea level a large portion of the excavation must be below the bed of the Chagres River, it will be seen to be many times cheaper to remove.

If open cut should be chosen instead of tunnel, the increased number of cubic yards would take but little more time to remove; for a portable railway system with cars and tracks galore would suffice for quick removal of material.

In regard to the comparative cost of maintenance and operation of the two routes it is axiomatically in favor of the San Blas route.

Now, in order to cite some authorities, let us take a brief extract from an appendix to a speech made in the United States Senate by Senator N. B. Scott, of West Virginia, on February 6, 1902:

Note 7.

Charles Prelini, in his "Practical Treatise on Tunneling," published 1901, gives the following table of cost of excavation in different kinds of soils, based on his examination of the actual cost of constructing many different tunnels through formations of like character, the number of which is given:

Nature of Soil.	No. of Tunnels.	Cost per Cubic Yard
Granite gneiss	56	$3.07 to $3.85
Schist	39	1.38 to 1.53
Triassic	3	—— ——
Jurassic	69	1.23 to 1.38
Cretaceous	34	.61 to .77
Tertiary and Modern	39	.33 to .61

Note 8.

An examination of the cost of the four great tunnels of the world—Hoosac, Mount Cenis, St. Gotthard and Arlberg—discloses the fact that the Arlberg, while one-third larger than the Hoosac cost $2,700,000 less, and was built in one quarter of the time. The Hoosac to-day could probably be built for one-half of the cost of its construction. Their relative cost per foot was:

Hoosac	$379
Mt. Cenis	356
St. Gotthard	229
Arlberg	154

In conclusion it may be said that many great men are advocating the San Blas route, and several of them firmly believe that *there* will eventually be constructed a great sea-level ship canal which will be on soil American, protected and controlled by the United States—a guaranteed world's highway for all time.

OBITUARY.

Kilburn Smith Sweet.

MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

KILBURN SMITH SWEET died July 15, 1904, after a brief illness, at his summer home at Quincy, Mass. He was born in Ramsey, Minn., February 25, 1872, the youngest of four sons of Capt. Thomas M. Sweet, who had served through the Civil War in the 24th Regiment, Massachusetts Volunteers. The father's health had been ruined by the exposures of army life, and in the year following the birth of this son he died. Two years later the mother also passed away. Deprived of his parents, the boy was dependent for a home upon other near relatives, with whom he lived most of the time until the age of seventeen. He then entered the Massachusetts Institute of Technology, and in 1893 was graduated from the course in civil engineering.

In the ensuing fall he returned to the Institute as assistant in civil engineering, later becoming instructor and remaining in that position until the time of his death. His time was divided between instruction in hydraulics, surveying and stereotomy. He was modest and unassuming in his ways, clear and direct in his thinking, and one who quickly won the interest and confidence of his students.

From the time of his graduation from the Institute his summer vacations were, with few exceptions, devoted to practical engineering work. He was thus employed on surveys, investigations or construction for the city of Newton, the towns of Winchester and Hopedale, the Associated Factory Mutual Insurance Companies, the Metropolitan Water and Sewerage Board, the Committee on Additional Water Supply for the City of New York, and the United States Geological Survey. Just previous to his death he had begun a summer engagement with Mr. Leonard Metcalf, member of this Society.

He joined the Boston Society of Civil Engineers in April, 1897, and at the time of his death was a member of the Committee on the Library, to the work of which he had for more than a year given much time. He was also a member of the New England Water Works Association.

In September, 1900, Mr. Sweet married Miss Jessie Louise Johnson, who survives him. He was a man of strongly religious character, which was quietly but consistently displayed in his conscientious performance of duty, in his readiness for every reasonable service, however humble, in his appreciation of the success of others, and in his patience and helpful sympathy toward his students.

DWIGHT PORTER,
CHARLES M. SPOFFORD,
Committee.

Association of Engineering Societies.

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PROCEEDINGS.

Technical Society of the Pacific Coast.

Directors' Meeting, San Francisco, Cal., May 13, 1904.—Held at the residence of Mr. Adolf Lietz, at San Rafael, which was preceded by a dinner, to which Mr. Lietz had invited the Directors for the purpose of getting them together and discussing informally the final arrangements for the spring meeting.

Present: Directors Dickie, Riffle, Schild, Wing, Uhlig, Lietz and von Geldern.

After the dinner the business before the Board was brought up by the Secretary and disposed of, after which the meeting adjourned, the guests returning to San Francisco.

Otto von Geldern, *Secretary.*

Spring Meeting, San Francisco, Cal., May 26, 27 and 28, 1904.—Officers—President, George W. Dickie; Vice-President, Franklin Riffle; Secretary, Otto von Geldern; Treasurer, E. T. Schild.

Directors—C. E. Grunsky, Adolf Lietz, Carl Uhlig, H. D. Connick and L. J. LeConte.

Committee—Past President E. J. Molera; Prof. C. B. Wing.

First evening (May 26th)—Reception to members and friends held in the hall of the Academy of Sciences.

The meeting was called to order by President George W. Dickie, who announced formally the opening of the first meeting and gave the general information for the itinerary of the next day.

The address of welcome was then delivered by the President, who referred to the past work of the Society and of its great future possibilities in influencing many lines of commercial development on the Pacific Coast. This interesting address will be published in full as a part of the Transactions of the Society.

The following telegram was received from Panama Canal Commissioner C. E. Grunsky, and was read by the President:

"Washington, May 26, 1904.

"Greeting to members and assembled guests. I wish all full measure of profit and enjoyment and success to first spring meeting.

"C. E. Grunsky."

Mr. F. P. Medina read a paper on the subject of the "Construction, Laying and Testing of the Commercial Pacific Cable," which was illustrated by various samples of cables for shore end, intermediate and deep-sea purposes.

Meeting adjourned until 2 P.M., May 27, 1904.

Second day (May 27th)—An excursion was arranged by Mr. Carl Uhlig to visit the Union Iron Works. A steam tug left the water front at 9.30 o'clock for the Potrero, where the attending members and their guests were entertained by Mr. Dickie and the officers of the establishment. The visitors were shown all the interesting objects, being taken from one to another of the shops by guides, who had previously grouped them, so as to explain and point out intelligently the great mechanical features to be seen here.

After the visit the party returned to the steamer, where the Committee on Entertainment, consisting of Mrs. Schild and Mr. Uhlig, had prepared a luncheon, enjoyed by all, after which the visitors returned to the city.

Second day (afternoon session)—Meeting was called to order at 2 P.M., by President Dickie.

The minutes of the evening session of May 26th were read and approved.

Mr. John Richards read an exhaustive paper on the subject of "Steam Turbine Motors," which, for lack of time, was not discussed, but upon suggestion by Professor Marx was confined to written communications to be sent to the Secretary.

Prof. F. G. Hesse read a paper entitled "Jet Pumps," in which a theoretical treatment of the efficiency of this kind of pump was made the main subject of discussion.

Mr. Marsden Manson presented an interesting paper entitled "The Reclamation of a Mountain Swamp," which was discussed by E. J. Molera.

Meeting adjourned until 8 o'clock P.M.

Second day (evening session)—The meeting was called to order at 8 o'clock P.M., by President Dickie, who announced the itinerary for the next day.

The minutes of the previous meetings and sessions were read and approved.

The following applications for membership were made and referred to the Board of Directors for ballot:

For members:

1. Robert Schorr, mechanical engineer, San Francisco. Proposed by A. E. Chodzko, Adolf Lietz and C. E. Grunsky.

2. Charles H. Parcell, civil engineer, city engineer of Sausalito. Refers to C. E. Grunsky, John Richards and George H. Wallis.

3. O. Holmer Phelps, heating and ventilating expert. Refers to Hermann Kower, F. G. Hesse and E. T. Schild.

4. Ralph E. Parker, civil engineer, Narrows, Oregon. Proposed by Marsden Manson, E. F. Haas and H. D. Connick.

The following papers were then read and opened for discussion:

1. "Pipes and Joints for High Pressure," Franklin Riffle.
2. "Vertical Railway Curves," H. I. Randall.
3. "Armored Concrete Construction," M. C. Couchot.
4. "Experiments in Driving Piles for a Foundation with a Steam Hammer," J. J. Welsh.

5. By title: "Skeleton Steel and Hollow Concrete Block Construction," S. Giletti.

Meeting adjourned.

Third day (May 28th)—A special car left Market and Fifth Streets at 10 A.M., in charge of Mr. H. D. Connick.

The party visited the power house at Eleventh and Bryant Streets, and also the so-called "Big Cut" of the Sante Fe Railway at Eighteenth and Iowa Streets.

The excursionists returned to the city by noon.

Third day (May 28th, afternoon session)—Called to order at 2 o'clock P.M., by Past President Molera.

The following papers were read and opened for discussion:

1. "Consideration of Uplift as Affecting the Design of Masonry Dams," Chas. D. Marx.

2. "Portland Cement Manufacture," C. J. Wheeler.

3. "Collection and Discussion of Material in County Highway Bridges," C. B. Wing.

The meeting thereupon adjourned, and the spring meeting ended with a banquet, held at the Palace Hotel, in the evening.

OTTO VON GELDERN, *Secretary.*

At the Banquet, held May 28, 1904 (Spring Meeting of the Technical Society), at the Palace Hotel, the following toasts were drunk and replies made, some of which are hereto annexed in full.

President George W. Dickie presided as toast-master, and called upon the speakers to respond.

1. The Technical Society of the Pacific Coast, Past President E. J. Molera.
2. The American Society of Civil Engineers, Mr. A. L. Adams.
3. The Electrical Engineering Fraternity, Mr. F. P. Medina.
4. The Mechanical Engineers of the Country, Past President John Richards.
5. The Architects, Our Co-workers, Mr. Henry A. Schulze.
6. The Relation of the Engineer to the Merchant, Mr. Charles Bundschu.
7. The Wives of the Engineers, Mrs. C. E. Grunsky.
8. The Improvements of OUR Rivers, Past President Marsden Manson.
9. The Removal of Telegraph Hill, Mrs. Chas. Bundschu.
10. The Engineer and the Astronomer, Professor A. O. Leuschner.
11. Our Glorious State—California, Mr. A. T. Herrmann.

THE AMERICAN SOCIETY OF CIVIL ENGINEERS, MR. ARTHUR L. ADAMS.

Mr. President, friends and wives of the members, and the members themselves, of the Technical Society of the Pacific Coast: You have placed the members of the American Society of Civil Engineers, residing in and about San Francisco, under lasting obligation to you, by extending to them, as you have, a very courteous and cordial invitation, regardless of their membership in this society, to attend your meetings, and particularly to attend at this banquet. On behalf of these members I wish to express to you my most hearty appreciation of your kindness and of the great

benefit which I have derived by listening to the very able papers which have been presented at this Spring meeting. They certainly would be a credit to any organization anywhere.

It is always easier to listen than to speak, even though it be not more pleasant sometimes. By your kindness you have a right to ask that I say something. I really know of no valid reason why I should not. It is not given to us all to speak words of wit and humor, which are always so welcome on an occasion of this kind, but it is at least given to each one of us, by expressing his views, to incite thoughts in the minds of others which may be of much greater value than those which he himself expresses.

It has been very kindly expressed to me that there is no restriction placed upon my selection of the subject upon which I should attempt to speak. I have noticed in the invitation which you have extended that the purpose of this meeting and of this banquet was to excite professional and social interests. The subject is broad. It has occurred to me that I might say a few words, which under these circumstances are certain to be of interest, not only to the members themselves, but to their wives (because I know wives are always interested in that which interests their husbands), upon what the California engineers have done for the engineering profession. In the early time, as the result of God's handiwork, this great state was spread out,—a state, I am sure, which, the longer we dwell in it, the more fully and forcibly are we impressed with its greatness, and with the wonders of its natural resources. He spread out upon the East the great mountains, upon which He lets fall, winter after winter, rain and their covering of snow. At their feet He spread out the great valleys, almost without rain, yet in every other respect of wonderful fertility. He spread out these great forests. He filled these mountains and these valleys with gold. And to this great opportunity He invited the people of the East,—indeed, the people of the world,—saying: Enter in, and take possession. It has been said that the Almighty gives no finished work to the hands of man. While that is true, He does give the engineer, in order that his work may be made finished. To the engineer He said: Enter in to this golden state, and prepare it for mankind. Make plain the way. Make possible the opportunities for the development of a great people. It is interesting for us to note in what way, and to what extent, response has been made to this call,—a call, certainly, no less divine, because it was extended to men of practical affairs, than is the call divine to that profession which preaches His Word. As the result of the work of comparatively few men, which accomplishment some now living may look back upon from its beginning, the bridle trail has been replaced by the railroad. The work has been done thoroughly, so far as external appearances go; and so far as those nicer problems relating to the adjustment of grades and construction cost to volume of traffic, that results may be given in haul at the least cost per ton mile, we have no reason to think that these problems have not been as carefully studied, as fully solved, in the case of California roads, as on any roads in the world.

The mining engineer has entered in, and from these rocks and these valleys he has taken gold to the hundreds of millions of dollars' worth; and he is to-day taking it from these mountains and these valleys in quantities second to only one other in the Union of States.

The irrigation engineer has entered in upon these valleys, almost barren of rain. Upon them he has brought the life-giving water, as a result of

which the coyote and the cactus have given place to the olive and the orange, and, may I add, too, these beautiful flowers which you see spread out upon this table before us in such profusion.

In place of the Indian canoe, which at one time navigated our waters, we have now sent forth from this city the very pinnacle of the engineer's accomplishments—these mighty battleships;—ships created—need I hesitate to say it—under the genius of your President, of such merit that it is recognized that none of greater efficiency are manufactured anywhere.

Our mountain streams are being transformed into electric currents for transmission over the longest lines in the world in commercial use. They have been brought to the centers of population, and are there bringing light into the dark places. We have before us this evening, as we sit around these tables, these beautiful lights, which in all probability are produced by energy emanating from these sources; and if not produced from these sources, are produced by a genius no less wonderful, no less meritorious, exercised upon our local generating stations.

To attempt to review all that the California engineers have done for the engineering profession in this state, would be to recite the history of California, with reference to its horticulture, its agriculture, its commerce,—yes, and even its social life. In the few minutes available I can do no more than thus briefly recite what has been accomplished. It is of exceeding interest, however, to trace, even in a few sentences, the process of evolution by which the engineer has wrought out this present condition. The original incentive to the coming to this state of its people was the promise of gold. The immediate problem which confronted the engineer was the extracting of that gold, and as a result of his study there were produced several epoch-making devices. For the using of the water of the streams, upon which he seized at once as a source of power for the solution of his problem, it was necessary to conduct it along precipitous mountain sides, and in many places across deep canyons. His genius rose to the occasion, and he was equal to the conditions confronting him,—conditions of scarcity of money and absence of means of transportation other than the backs of man and beast. He produced the steel-riveted pipe. He used it in the lightest gauges under pressures which were phenomenal, and which would have been appalling to the hydraulicians of other countries. He evolved a type of pipe which has become standard in engineering, and which is now in use practically everywhere.

In studying this problem he also produced another invention, only less important than that mentioned, the hydraulic giant, by which the water, brought from these distant sources under great pressure, was made to tear the earth asunder, and to separate, by means of other devices, the gold from the gravel. How nicely has the mechanical engineer stepped in and supplemented this whole invention. He saw the necessity for cheap power. He saw this tremendous energy issuing in the jet of the hydraulic giant. He applied the impulse wheel, and we have produced another epoch-making invention originated in California. We have the impulse water wheel, a type distinct in itself, a type of great value, a type which the world has come to recognize as of especial value in a field for which nothing else exists, a type of wheel which is now in use in every country of the globe.

In the irrigation of the plains it became at once apparent to the irrigation engineer that water must be stored in these mountain valleys at such

elevations that it could be brought readily to the plains to be watered. Again he was confronted by adverse conditions, difficulties in transportation, the scarcity of money, where great results must be achieved with limited means, and he evolved many striking types of construction; some of them of great value, some of them of great interest as experiments whose real value is as yet not determined. We have originated the rock-fill dam. We have originated the dam of curved plan, depending entirely upon its arched action for its resistance to the water pressure. We have originated the steel-core dam, while here dams of cribwork and dams of earth have been carried to heights still unsurpassed elsewhere.

If I were to take time, and if I had greater familiarity with all the various lines of engineering, I might enumerate many other striking inventions which have been brought to a high degree of perfection on this coast by the engineering profession, and which reflect great honor upon the engineers of this state. The question naturally arises now, as to whether or not there have been rewards for these great achievements. The very fact that these achievements have been adopted elsewhere, that their merits have come to be recognized by the profession at large, is itself the greatest reward. And yet reward has not been lacking in a financial way. It should be a matter of pride to the members of the profession at this day that to California has come the president of the greatest aggregation of railroad capital that has ever existed, to find the brains for the management of that great property, and he has come to the engineering profession to find those brains. It should be a matter of pride with us that the greatest salaries that have ever been paid to engineering specialists have been paid by London capitalists to men trained in the mines of California. It should be a matter of the greatest pride to us that there sit around this board men whom it is unnecessary to enumerate, whose reputation is world-wide.

If what I have said seems to be in the nature of felicitation, it is not because I wish so to be understood. I recognize its dangers. It leads to egotism, which leads to bigotry, and these are ever a drag upon rather than an incentive to progress. I speak thus, however, that we may, as engineers, more fully appreciate the value of our heritage,—the value of that which has been done by the men who have preceded us here in this state; that we may be inspired to greater activity; that we may realize that the acceptance of this heritage imposes a corresponding responsibility, which we must meet if we are to prove ourselves deserving. I speak also in this vein because I am exceedingly jealous of the reputation of the engineering profession in California, and am anxious that it may receive the recognition to which its works entitle it. To this end, it is necessary that we should have a just appreciation of that which the profession here has contributed to the sum of engineering knowledge. And having such appreciation, it is necessary that we maintain at all times that degree of organization, the necessity for which I was so glad to hear your president dwell upon in his address the other evening, which is so essential in order to get before our profession at large a knowledge of the work which is accomplished here.

To this end no influence has contributed so much as "The Technical Society of the Pacific Coast." I am glad that you are already planning the further expansion of that influence; and you may be always assured of the hearty sympathy of the members of the American Society of Civil Engineers, the names of many being on your membership rolls.

The Electrical Engineering Fraternity, by Mr. F. P. Medina.

Mr. Chairman, Members of the Technical Society, ladies and gentlemen: In responding to the toast proposed, I have first to call attention to the social process that has created the engineer; how, in the beginning, when Science and Utility were wedded, the engineer was the offspring of their union. And it would make very interesting matter to trace the history of the engineering professions from ancient times, when, the concept of his possible functions being exceedingly limited, the same individual was at once civil and mechanical engineer and architect, to the present, when function has become so heterogeneous. The Electrical Engineer is the product of this differentiation of functions, which has been going on through the ages, and is the youngest member of the family. So it is no wonder that we look to the future for his greatest achievements, without disparaging his work in the past. Notwithstanding the problems of long distance transmission that have already been solved, it is not too much to expect that the future will see problems of even greater magnitude as well solved; notwithstanding the manifold uses to which electricity has been put in the past—uses, standing to society in a relation analogous to that in which nervous force stands to the individual organism—the future will disclose uses hitherto undreamt of. In the still prevailing controversy over the rightful position of Science in the education of the individual, Science appears to me to be like the little gray-gowned Cinderella, who was destined one day to be transformed into the richly robed princess, and finally to wear the crown and wield the scepter as queen. It is not putting it much too strongly to call Science the mother of civilization, and while, in this practical old world, Utility is honored enough, I say "All hail, to the little gray-gowned Mother of Civilization!"

The Mechanical Engineers of the Country, by Past President John Richards.

Mr. Toast-master, ladies and gentlemen: My friend, Mr. Dickie, is always assigning to me some difficult work. He well knows the vague meaning of Mechanical Engineer. If properly construed, or construed in fact, it covers nearly all constructive work and is chief among the engineering professions. I do not represent the profession to an extent which would justify my selection to speak to this toast. In fact I am a deserter, not so much from choice as from necessity. The art has run away from me and has left me high and stranded after an honest struggle of twenty-nine years in the works.

Somewhere else the result would have been different, but on this coast the mechanical engineer is confronted with a chaos of problems that defy classification. Steam machinery, in its multifarious forms—marine propulsion—mining machinery—hydraulics—pneumatics and half a hundred more divisions of his art, with all of which he may be brought into contact, make up, as I said, an indefinite calling covered by the term "Mechanical Engineering."

We keep pretty well to the front on this coast, notwithstanding the impediments named. One may go into any of our works out here and order a man-of-war, a wheel barrow, a locomotive or an iron fence, and his order will be entered as a matter of commonplace practice. In the Eastern States they enjoy the advantages of organized production in specialized manu-

factures, and by the economy thus gained they relieve us of the great mass of what may be called engineering manufacture, leaving us the special and difficult part and all the risks. Still we manage to keep along, and sometimes we "carry coals to New Castle." In ships of war, cable railways, hydraulic and mining apparatus of all kinds, plowing and hoisting machinery, we have a foremost place in respect to the world's practice.

Not only in machines, but in men, we are well represented. If the members of this Society were withdrawn from the South African mines, it would cause a great change there. Our work is a little rough sometimes, and has to be, because of its cost to produce. A prominent manager in the east said to me, last year, in respect to a machine he was making, "It costs me more to sell that machine than it does to make it." This was true; the selling expense exceeded the labor account. We are not likely to do any of that kind of selling out here. It is a system of production that is not likely to endure and should not endure.

The Improvement of Our Rivers, Mr. Marsden Manson.

Mr. President, although you have been credited with making a great many mistakes, and with having made them a long time ago, and although you have selected for me a subject that cannot be thought a dry one, I think that you have made a mistake in calling on me to talk. It is a grave mistake to call on a man to make a speech after dinner, unless he is a gifted after-dinner speaker.

Tributary to the Bay of San Francisco we have two rivers, and a number of smaller streams. Some of them are even called sloughs. But one of our important cities—Stockton—has grown so great,—so important, in the commercial development of this state, that it does not like the name "slough," and consequently we have "Stockton Channel." The same way with our neighbor Oakland. I was once taken to task for saying that Oakland had no important water front, and I came very near replying that I did not know that Oakland had any water front at all,—that it was worse off than San Francisco; it sold its water front many years ago for a schoolhouse and a bridge, and now has not even the schoolhouse and the bridge. But our rivers are of much importance, not only in the matter of navigation, but as carriers of flood water. They have to pass volumes of flood water through an enormously rich country. Unless those waters are passed in channels designed and arranged by the technical man to fit the duties which they have to perform, enormous damages are done. To-day, the measure of damage done by floods, on the crops that we should have had this summer and fall, is measured in the enormous sum of five millions. Unfortunately, in dealing with those rivers, we have a number of interests to adjudicate. First, the United States government controls those portions which are navigable. Second, the state steps in, and it unfortunately steps in through a non-technical commissioner of public works.

We have "The Sacramento River," conducted by a very good collection of business men. For a number of years it was edited by a good editor, and now an excellent lawyer is ready to write briefs on the subject. I think it is time for our technical men to step forward and take hold of the subject of river treatment, write about it, think about it, study it up. The technical engineers pay attention to these matters. They have studied the conditions in this state, they have brought with them from other states,

and from other countries, a knowledge of what has been done upon other rivers, they keep in touch with the literature of the subject; and yet, in a recent river convention held in this city, in which the interests and development of those rivers were considered, it was practically declared that the technical engineer was not the right man to deal with these questions; that he must be like the reporter who was told by the managing editor that he would like to have a man approach his subject knowing absolutely nothing about it; as he would then be able to write an unprejudiced article from an unbiased standpoint.

In regard to taking hold of a technical subject, the general idea is that you want a man who *does* know something about his subject,—who knows as nearly all about it as it is possible for the human intellect to know. To find that idea reversed was a little of a surprise to me.

Again, this same authority wanted men who had had experience on Mississippi River work. He forgot that, within our borders, were three members of the Mississippi River Commission, all engineers, all trained in that capacity; and yet the idea was advanced, and I am sorry to say it was well supported in that body, that we should have men who knew nothing about California rivers, but who had had experience elsewhere.

In those rivers we have in the neighborhood of a thousand miles of navigable channel. Those channels are being depleted and injured by wash from the hills and by unavoidable mining débris, and it is the province of the engineer to put these channels, not only in their originally good condition, but in a still better condition. Around this bay there centers something in the neighborhood of twenty thousand square miles of rich, alluvial territory. The greater portion of this area is intersected by this thousand miles of navigable channels. We have no idea of the scope of work necessary to put these lands and channels into shape for the best interests of our people, and there lies before us, in this, one of the great fields of work of our profession.

It is not only the civil engineer who has to deal with these problems. The manufacturing and technical chemist must build the works for developing the cement which will be needed in the construction of immense hydraulic works. The chemist will have the waters and the soils of that same region to deal with. The engineer, who devotes himself to railroad work, must not only build the miles of road that will traverse each side of that section, he must cross-section it, gridiron it, with numberless tracks. So we have before us a field of enormous work and a region of enormous wealth.

THE ARCHITECTS, OUR CO-WORKERS, MR. HENRY A. SCHULZE.

Mr. Toastmaster, Ladies and Gentlemen, when it was announced to me that I would be expected to respond to the toast "The Architects," I could not but feel that we had quite a number of the architectural profession in our membership who could and would voice a response in a far happier vein than myself, far more in touch and tune with the festive and professionally fraternal occasion which we are gathered here this evening to participate in and to enjoy and which so fittingly marks the close of our more than enjoyable and profitable spring meeting, yet withal there was no desire on my part to shirk this obligation in favor of some one else in that it occurred to me that at about the middle of my professional career it was my fortune for quite a span of years to have the engineering side of architecture pre-

dominate to a large degree in the activities of my life. During that time my intercourse was fully as much, if not more, with engineers than with architects which thus perhaps put me in closer sympathetic accord with the aspirations and ambitions of each profession than, sometimes, is manifest in its individuals; it is often asserted by our engineer friends, with considerable show of right for a basis in fact, that the architect, through indifference or the cultivation of a poetic, artistic temperament, somewhat willingly allows the warping and clouding of his judgment against what is precise and mathematically capable of demonstration and looks askance, not to say with disdain, on the efforts of the engineer to intelligently apply the materials of construction at hand with the least waste and the least divergence from directness, that the architect but incidently acknowledges that the law of gravity has some subtle associates which are often ignored by him, to which, in reply, the engineer must complacently listen to the assertion that the engineer knows nothing of the subtleness of a line of beauty or the pleasure aroused by the harmony of proportion, that the trend of his education and nature does not bring him to the analysis of that which is beautiful, nor to the esthetic elements which also underlie all construction problems and only to that which is eminently practical and useful.

Each side has indulged in these reflections with some show of justness, much to the detriment of each other and at the expense of high and satisfactory results, beneficial alike to each other; many modern constructive problems involve the intelligent activities of the two professions to such an extent, they overlap and commingle so closely, that it is difficult to determine just where the responsibilities of the one profession end and where those of the other begin, the trend of modern practice being more and more in that direction, therefore, engineer and architect alike should be governed solely by that breadth, largeness and generosity which are characteristic of each of the two professions classed among the most exacting and important of all professions, developing thus to that lofty and gratifying ideal "fraternity" with all its encouraging rewards.

Directors' Meeting, San Francisco, June 24, 1904.—Held at the office of the Secretary.

The Treasurer presented bills for the excursions and banquet of the spring meeting, which were approved and ordered paid.

The following were elected to membership upon count of ballots:

1. Robert Schorr, mechanical engineer.
2. Chas. H. Parcell, civil engineer.
3. O. Holmer Phelps, heating and ventilating expert.
4. Ralph E. Parker, civil engineer.

The Secretary was instructed to notify the members that there would be no meeting during the month of July.

Adjourned.

Otto von Geldern, *Secretary.*

Regular Meeting, San Francisco, Cal., August 5, 1904.—Preceded by a meeting of the Board of Directors, called to order at 7 o'clock P.M., by President Dickie.

The purpose of the meeting was to consider the necessary arrangements for the autumnal meeting of the Society.

It was agreed that the most suitable time would be December 9th and 10th. The Secretary was instructed to circulate a notice requesting members to submit suitable papers to be read on that occasion, and to notify the Secretary in time to have the papers set into an outlined program. The meetings are to be held in the Mechanics Library Building, and will be open to the public.

After discussing the details of the proposed meeting and the available locations for excursions, the regular meeting was called to order by the President.

The minutes of the spring meeting were read and approved.

Mr. Dickie left the meeting, and the Vice-President, Mr. Riffle, took the chair.

Mr. H. L. Demeritt thereupon addressed the members on the most interesting subject of "The Removal of Shag Rocks and Arch Rock in San Francisco Harbor," explaining the methods employed by the contractor in drilling, blasting and dredging the material. He referred to the object lessons taught by contact with this comparatively new and hazardous problem, and related in a highly interesting manner the details and causes of failures and the final satisfactory result of this great work.

The Society expressed its appreciation by a vote of thanks tendered Mr. Demeritt.

The meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

ASSOCIATION

OF

ENGINEERING SOCIETIES.

VOL. XXXIII. OCTOBER, 1904. No. 4.

PROCEEDINGS.

Boston Society of Civil Engineers.

BOSTON, SEPTEMBER 21, 1904.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.45 o'clock P.M. President Frederick Brooks in the chair. Eighty-two members and visitors present.

The record of the last meeting was read and approved.

Messrs. James F. Monaghan and Charles H. Parker were elected members and Mr. Francis E. Adams an associate of the Society.

Mr. J. R. Worcester read a communication from the commission appointed to revise the building laws of the Commonwealth, inviting the Society and its members to submit in writing any suggestions which they desired to make with reference to amendments. Mr. Worcester stated that the commission had been furnished with a copy of the changes adopted by the Society at its March meeting.

The President announced the death of two members of the Society: Kilburn S. Sweet, who died July 15, 1904, and Reuben Shirreffs, who died August 31, 1904.

By vote of the Society the President was requested to appoint committees to prepare memoirs. The President appointed as a committee to prepare memoir of Mr. Sweet, Messrs. Dwight Porter and C. M. Spofford; and to prepare memoir of Mr. Shirreffs, Messrs. A. D. Flinn and J. C. Chase.

On motion of Mr. Wason the following vote was passed, Voted, That the Board of Government be instructed to consider the advisability of inviting the visitors of the Institution of Civil Engineers to Boston, and that they be given full powers to act as they deem best in this matter.

Mr. Sanford E. Thompson then read the paper of the evening entitled, "The Strength of Concrete." The paper was illustrated by numerous diagrams.

A general discussion followed the reading of the paper in which Messrs. J. R. Worcester, Wm. Parker and C. M. Spofford took part.

Adjourned.

S. E. TINKHAM, *Secretary*.

Sanitary Section.

Boston, Mass., October 12, 1904.—The regular meeting of the Sanitary Section of the Boston Society of Civil Engineers was held at the Copley Square Hotel, October 12, 1904, at 7.15 P.M.

The meeting was preceded by a dinner which was attended by 38 members and guests and the attendance at the meeting was 52.

It was voted that the reading of the records of the last meeting be dispensed with.

The following were elected to membership in the Section: Arthur Morgan, Charles W. Ross, William F. Morse.

The paper of the evening was read by Mr. M. N. Baker, associate editor of the *Engineering News*, the subject being "A Recent Visit to Twenty-four British Sewage Works." The paper was discussed by Professor L. P. Kinnicutt, Mr. H. W. Clark and others.

On motion of Mr. H. P. Eddy, the thanks of the Society were voted to Mr. Baker for his interesting and instructive paper.

Voted to adjourn.

William S. Johnson, *Clerk.*

Boston, October 19, 1904.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.40 o'clock P.M.; ninety-four members and visitors present.

The record of the last meeting was read and approved.

The following were elected members of the Society: Messrs. Elliot R. B. Allardice, Walter L. Anthony, George P. Frost, George A. Johnson, Albert E. Kimberly, William N. Patten, Charles H. Pierce and John E. Porter.

The thanks of the Society were voted to Mr. Fred E. Ellis for courtesies extended to members of the Society on the occasion of the excursion to the new highway under construction across the Lynn marshes, on July 20, 1904, and to Mr. George Phillips for courtesies on the occasion of the excursion to Moon Island and the Sewage Pumping Station, on September 29, 1904.

The first paper of the evening was by Mr. Frank W. Hodgdon entitled "Boat Harbors on the South Coast of Massachusetts." The paper was illustrated by plans and lantern slides.

The second paper was by Mr. John E. Cheney on the construction of the Cambridge Bridge. This paper was fully illustrated by lantern slides.

Adjourned.

S. E. Tinkham, *Secretary.*

Engineers' Club of St. Louis.

St. Louis, Mo., Thursday, June 9, 1904.—The Engineers' Club of St. Louis entertained the members of the British Institution of Mechanical Engineers and the members of the American Society of Mechanical Engineers upon a boat trip up the Mississippi River.

The opportunity for seeing the river at a time of high water was taken advantage of by some 250 members and guests.

The steamer Cape Girardeau, chartered for the occasion, left the dock at the foot of Locust Street shortly after 1 o'clock, luncheon being served on the boat.

The visitors being anxious to see the junction of the Missouri with the Mississippi, the proposed stop at the Chain of Rocks was abandoned, and the trip continued nearly to Alton.

As many of the guests had dinner engagements, the return was so planned that they might meet these engagements, the landing being made at 5.30.

The day was ideal and the trip was in every way a pronounced success.

R. H. FERNALD, *Secretary.*

ST. LOUIS, MO., SATURDAY AFTERNOON, JUNE 25, 1904.—About 50 members of the Engineers' Club of St. Louis, with ladies, responded to the kind invitation of the Honorable Adalbert von Stibral, Commissioner-General of Austria, to a private view of the engineering exhibits in the Austrian Pavilion at the World's Fair Grounds.

The guests were cordially received by the Commissioner, and after an inspection of the pavilion were directed to one of the large porches, where refreshments were served.

R. H. FERNALD, *Secretary.*

ST. LOUIS, MO., AUGUST 6, 1904.—An invitation was extended to the members of the Engineers' Club of St. Louis to attend a lecture on "Liquid Air," given under the direction of the Department of Liberal Arts, by Dr. Petavel, of the British Royal Commission, in the Jury Room of the Liberal Arts Building.

Those who attended were highly entertained and greatly interested in the lecture, which was well illustrated and especially adapted for the occasion.

R. H. FERNALD, *Secretary.*

ST. LOUIS, MO., WEDNESDAY, SEPTEMBER 14, 1904.—The Engineers' Club of St. Louis entertained the delegates to the International Electrical Congress at an informal luncheon, in the main hall and court of the Electricity Building, World's Fair Grounds.

Although somewhat difficult to estimate the number present, the general opinion was that about seven hundred availed themselves of the Club's invitation, which fortunately was the number provided for by the caterer.

R. H. FERNALD, *Secretary.*

584TH MEETING, ST. LOUIS, MO., SEPTEMBER 21, 1904.—The 584th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 709 Pine Street, Wednesday evening, September 21, 1904.

In the absence of both President Ockerson and Vice-President Moore, Mr. Edward Flad was appointed to the chair.

There were present 18 members and 2 visitors.

The minutes of the 583d meeting and of the special meetings and gatherings held during the summer were read and approved, and the minutes of the 370th, 371st, 372d and 373d meetings of the Executive Committee were read.

The following names were proposed for membership and referred to the Executive Committee for action: Leonard Alleck Day, Halbert Paul Hill, Carl Edward Julihn, Charles Francis Müller and John Bice Turner.

Upon motion of Mr. Bremecke the following committee was appointed by the Chair to investigate the question of new quarters and to report as soon as possible to the Club—one member of the committee to be a member of the present Governing Board: W. G. Brenmecke, H. H. Humphrey, E. E. Wall. W. A. Layman and A. H. Zeller.

The paper of the evening upon "Some Experiences as a Municipal Contractor" was presented by Professor F. S. Spalding, of the University of Missouri, and brought out discussions from Messrs. Childs, Broderick, Flad, Helm, Greensfelder and Spalding.

Adjourned.

R. H. Fernald, *Secretary.*

St. Louis, Mo., September 24, 1904.—On the evening of September 24, the Engineers' Club of St. Louis gave a smoker in the Missouri Building, World's Fair Grounds, in honor of the members of the American Institute of Mining Engineers, who were visiting the Exposition. Twenty-nine members of the Club were present and about 100 guests.

After brief but happily chosen introductory remarks, Mr. Ockerson, the President of the Club, introduced Dr. Raymond, the Secretary of the Institute of Mining Engineers, who responded in his usual cordial way.

After announcements by Mr. Wheeler, the local Secretary of the Mining Engineers, relating to the entertainment of the visitors, Mr. Klepetko, consulting engineer for the Amalgamated Copper Co., presented a paper on the "Mineral Resources of the United States."

Following this, Dr. E. W. Parker, of the U. S. Geological Survey, described in detail the U. S. Geological Survey Fuel Testing Plant in operation in the Mining Gulch at the Exposition, and extended a cordial invitation to those interested to visit the plant.

Refreshments suitable for the occasion were served throughout the evening, and the informality of the affair was to a large extent responsible for its success.

R. H. Fernald, *Secretary.*

St. Louis, Mo., Sunday, September 25, 1904.—The Engineers' Club of St. Louis was invited, by the local committee of the American Institute of Mining Engineers, to join the American Institute of Mining Engineers and the Jurors of the Engineering Departments for a private view of the exhibits in the Mines and Metallurgy Building.

About 45 members of the Club took advantage of this exceptional opportunity, passes having been furnished through the kindness of Mr. W. B. Stevens, the Secretary of the Exposition. The total number present was about 200.

During the inspection of the exhibits, President Francis, Director Skiff and Secretary Stevens, of the Exposition Company, and Mayor Wells, of St. Louis, dropped in, and after a few impromptu remarks, the company adjourned to the balcony of the building where luncheon was served.

Following luncheon, the party went through the north end of the gulch, giving especial attention to the "Thermit" demonstration and the Fuel Testing Plant, returning in season to take the automobiles for a trip around the grounds and the city.

R. H. Fernald, *Secretary.*

St. Louis, Mo., Friday Evening, October 7, 1904.—The Engineers' Club of St. Louis entertained the members of the International Engineering Congress at a smoker in the Missouri Building, World's Fair Grounds.

Over 50 members of the Club were present together with about 250 guests.

The company met in the large assembly hall, and was called to order by Mr. Ockerson, President of the Club. Mr. Ockerson's introductory remarks were followed by brief, informal "speeches" by Mr. E. S. Corthell, member of the Am. Soc. C. E., New York City; Sir William White, K.C.B., F.R.S., President, Institute of C. E., England; Robert Moore, Past-President, Am. Soc. C. E., St. Louis, and Professor K. E. Hilgard, member Am. Soc. C. E., Zurich, Switzerland.

After the remarks and cigars had been enjoyed, refreshments were served in the various rooms of the building. Music for the evening was furnished by an orchestra and by a vocal quartet.

R. H. Fernald, *Secretary*.

585th Meeting, St. Louis, Mo., October 19, 1904.—The meeting was held at the Club rooms, 709 Pine Street, Wednesday evening, October 19, 1904.

In the absence of President Ockerson, Vice-President Moore presided. There were present 27 members and 6 visitors.

The minutes of the 584th meeting of the Club and the records of the smoker of September 24th and the visit to the Mines building, Sunday, September 25th, and the smoker of Friday evening, October 7th, were read and approved.

The minutes of the 374th meeting of the Executive Committee were also read.

The following were elected to membership in the Club: Leonard Alleck Day, Halbert Paul Hill, Carl Edward Julihn, Charles Francis Müller, John Bice Turner.

Owing to frequent absence from the city Mr. E. A. Hermann found it necessary to tender his resignation as a member of the Executive Committee. The resignation was accepted, and Mr. A. O. Cunningham and Mr. A. P. Greensfelder were nominated to fill the vacancy. Mr. Greensfelder was elected, receiving 14 of the 26 votes cast.

A very complimentary notice regarding the hospitality of the Engineers' Club of St. Louis during the Exposition period, published in the editorial section of the *Engineering Record* of October 15th, was read by the Secretary.

Upon motion of Mr. H. A. Wheeler, it was decided to dispense with the services of the attendant at the Club Rooms at the end of October.

Mr. W. G. Brennecke, Chairman of the Committee on new quarters, made an informal report of progress. He indicated that the Local Chapter of the American Architectural Institute would hardly care to join the Engineers' Club in the new quarters. The Committee had under consideration the following possible places:

1. The present location, 709 Pine Street.
2. Library, down town; meetings elsewhere.
3. Washington University Club, 29th and Locust Streets.

4. Academy of Science, Olive, near Vandeventer Avenue.

5. Y. M. C. A., Grand and Franklin Avenues.

Mr. C. D. Purdon presented his interesting paper upon "The Classification of Engines for Bridge Loading," which was discussed by Messrs. Fay, Moore, Fernald, Mogensen, Purdon, Turner, and Greensfelder.

Adjourned.

R. H. FERNALD, *Secretary.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., MONDAY, OCTOBER 10, 1904.—The regular meeting of the Civil Engineers' Society of St. Paul was called to order by President Starkey at 8.15 P.M.

Eight members in attendance.

Minutes of previous meeting read and approved.

The secretary was directed to have one hundred membership cards printed.

Messrs. Munster, Bernier and Forbes were named by the President as a committee on society badge to report at the next meeting.

The following applicants were unanimously elected to membership:

Charles Olney Cook, care N. W. Fuel Co.

J. Henry Fitz, 34 Union Block.

T. Milton Fowble, 34 Union Block.

Russell Saville Fuertado, Somerset P. O., Wisconsin.

Nathaniel Hanson, 675 Edgerton Street.

Kristian W. Tanner, Gilfillan Block.

Alfred H. Wheeler, 816 Globe Building.

W. P. Whitten, Gen. Off. G. N. R'y Co.

C. L. ANNAN, *Secretary.*

Technical Society of the Pacific Coast.

REGULAR MEETING, SAN FRANCISCO, CAL., SEPTEMBER 2, 1904.—Called to order by Vice-President Franklin Riffle.

The minutes of the last regular meeting were read and approved.

The following were elected to membership after a count of the ballots: Chas. E. Moore, civil engineer, Santa Clara, Cal.; James C. Bennett, mechanical engineer, Oakland, Cal.; Eugene T. Thurston, civil engineer, San Francisco, Cal.

Mr. H. A. Diehl discussed "Pumice" as a comparatively new and available building material, having gained the conviction that if some material other than the heavy masonry for adorning tall buildings could be found, of lighter weight, yet sufficiently strong to replace the brick, terra cotta and freestone employed at present, some substance which might at the same time be fire-proof, an important departure from ordinary building methods might become possible. The subject was discussed at length by members. The meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

Technical Society of the Pacific Coast.

REGULAR MEETING, SAN FRANCISCO, CAL., OCTOBER 7, 1904.—Called to order at 8.30 o'clock, P.M. by President Dickie.

The minutes of the last regular meeting were read and approved.

In the consideration of the fall meeting it was agreed that the dates for the gatherings be December 1st, 2d and 3d; that is, on the first Thursday, Friday and Saturday of the month.

The following program for the meeting was arranged:

THURSDAY, DECEMBER 1ST.

Evening session, beginning at 8 o'clock P.M.

1. Reception and Address of Welcome, by the President.
2. "Hydro-Electric Power Development and Transmission in California," by Robert McF. Doble.

FRIDAY, DECEMBER 2D.

Afternoon session, beginning at 2 o'clock P.M.

1. "Water Power and Electricity in California," by George W. Nichols.
2. "Hydro-Electric Power Generation from the Consumer's Standpoint," by James C. Bennett.
3. "Engineering and the Law," by Frank P. Medina.

Evening session, beginning at 8 o'clock P.M.

1. "Trade Schools," by Edward T. Hewitt.
2. "Phenomena of Machine Operation," by John Richards.

SATURDAY, DECEMBER 3D.

Afternoon session beginning at 2 o'clock P.M.

1. "Fuel Oils, Their Physical Properties," by Paul W. Prutzman.
2. "Durability of the Materials of Masonry Used in San Francisco," by Marsden Manson.
3. "Reclamation of Tidal Areas," or another subject in lieu of this, by Otto von Geldern.

The meetings to close with a banquet to be held at some suitable place to be chosen.

Committee on banquet: Messrs. Uhlig and Schild.

Committee on holding meetings: Messrs. Connick and von Geldern.

It was also suggested that a communication be sent to the Mechanics Institute to request the Trustees to increase the scope of the Technical Library as much as possible, in order to increase its usefulness to engineers and that the co-operation of a committee from the Technical Society be suggested to them for the purpose of adding suitable literature to this part of the Library.

The Secretary was instructed to write such communication to the Trustees of the Mechanics Institute, offering such co-operation if acceptable to them.

Meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

Montana Society of Engineers.

THE regular meeting of the Society for October, 1904, was held in the Society Room, 225 North Main Street, Leyson Block, on Saturday, October 8th, at 8 P.M., with President Moulthrop presiding, and a large number of members in attendance. The minutes of the last meeting were approved. The application of Mr. Wm. T. Jackson for membership in the Society was read, approved and the Secretary was instructed to send out the necessary ballots. Treasurer Barker read some new rules under consideration by the Association of Engineering Societies, and was instructed to vote "no" on the section that proposed a yearly tax on all members, active, honorary and associate. Mr. C. W. Goodale began a discussion of the U. S. Mining Laws, but gave way to Mr. Geo. H. Maxwell, who spoke at length, having for his theme, "Irrigation Projects of the United States." An interesting discussion by several members followed his remarks. The members expressed their appreciation of Mr. Maxwell's address by a vote of thanks. On motion, the discussion of U. S. Mining Laws was deferred until the November meeting.

The Society then adjourned.

CLINTON H. MOORE, *Secretary.*

Association of Engineering Societies.

Vol. XXXIII. **November, 1904.** No. 5.

PROCEEDINGS.

Engineers' Club of St. Louis.

586th Meeting, St. Louis, November 2, 1904.—Held at the rooms of the Club. President Ockerson presided. There were present 32 members and 2 guests.

The minutes of the 585th meeting were read and approved, and the minutes of the 375th meeting of the Executive Committee were read.

Mr. W. G. Brenneke, Chairman of the Committee on New Quarters, reported that the proposition for having the library down town and meeting room elsewhere was too expensive. There are no possibilities of getting quarters either at the Washington University Club or the Y. M. C. A. The plan seemed to narrow down to the Historical Society or the Academy of Science, probably the latter. The committee hoped to report definitely at the next meeting.

Mr. S. B. Russell, Chairman of the World's Fair Committee, gave an outline of the plans for the reception to the Iron and Steel Institute, Friday evening, November 4th, at the Kentucky Building, World's Fair Grounds. The Secretary added a few details, and explained the proposed visit of the Club to the Mines and Metallurgy Building, World's Fair Grounds, Sunday, November 6th, through the kindness of the Reception Committee of the Iron and Steel Institute.

According to the by-laws of the Club, the following were nominated to serve on the committee to nominate officers for the next year: W. G. Brenneke, S. B. Russell, R. S. Colnon, H. J. Pfeifer, J. L. Van Ornum, E. R. Fish, E. E. Wall and R. L. Murphy.

Of this number the following were elected: W. G. Brenneke, R. S. Colnon, E. R. Fish, R. L. Murphy and S. B. Russell.

Mr. S. B. Russell proposed an amendment to the Constitution, Article III, Section 1, so that it shall read: "The officers of the Club shall be a President, First Vice-President, Second Vice-President," etc.—*i. e.*, providing for two Vice-Presidents instead of one.

Mr. W. G. Brenneke suggested the addition of another Director, so that the Executive Committee should consist of seven members, namely: President, two Vice-Presidents, Secretary and three Directors.

Upon motion of Mr. Flad, seconded by Mr. Russell, the President appointed a committee, consisting of Edward Flad, S. B. Russell and R. H. Phillips, to draw up the necessary amendments to conform to the above

suggestion. The committee was instructed to report at the next meeting of the Club.

The paper of the evening, by Prof. A. P. Winston, of Washington University, upon "The Incorporation of Trade Unions," was listened to with unusual interest, and provoked discussion from Messrs. McCulloch, Borden, Childs, Bryan, Chaphe, Van Ornum, Flad, Turner, Phillips and Professor Winston.

Upon motion of Mr. Zeller, a vote of thanks was extended Professor Winston for his paper.

Adjourned. R. H. FERNALD, *Secretary.*

ON Friday evening, November 4th, the Engineers' Club of St. Louis tendered an informal reception to the members of the Iron and Steel Institute, with their ladies, at the Kentucky Building, World's Fair Grounds. About 70 members of the Institute and ladies were present, and about the same number of members of the Club and other invited guests.

Through the kindness of Mr. Hughes, Secretary of the Kentucky Commission, the Kentucky Building, which is admirably adapted for an occasion of this kind, was reserved for the exclusive use of the Engineers' Club and its guests.

R. H. FERNALD, *Secretary.*

ON November 6th, at 10 A.M., the Engineers' Club of St. Louis was entertained by the Reception Committee of the Iron and Steel Institute at a private view of the Mines and Metallurgy Building, World's Fair Grounds. The total attendance, including the members of the Iron and Steel Institute, the Engineers' Club and invited guests, among whom were many ladies, was over two hundred.

Luncheon was served in the building about 1 o'clock. After a visit to two or three outside exhibits, automobiles were taken through the city to the foot of Walnut Street, where Colonel Thompson entertained the party upon his house boat, which had just arrived from New York.

R. H. FERNALD, *Secretary.*

Boston Society of Civil Engineers.

BOSTON, NOVEMBER 16, 1904.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.40 o'clock. President Frederick Brooks in the chair. About 200 members and visitors present, including ladies.

In the absence of the Secretary, Mr. Richard A. Hale was elected secretary *pro tem.*

The record of the last meeting was read and approved.

Messrs. Joseph P. Palmer and James M. Siner were elected members of the Society.

A memoir of Charles W. Folsom, prepared by a committee of the Society, was read by the Secretary in the absence of any member of the committee.

The President announced the death of James T. Boyd, a member of the Society, which occurred on November 3, 1904. By vote of the Society, the

President was requested to appoint a committee to prepare a memoir. The President has appointed as that committee Messrs. Ira N. Hollis and Frank B. Dowst.

The literary exercises were by Mr. Desmond FitzGerald, who gave a talk on his work in the Philippines and described interesting street scenes in Manila. The talk was illustrated by a large number of beautiful lantern slides.

Adjourned. R. A. HALE, *Secretary pro tem.*

Montana Society of Engineers.

THE regular meeting of the Society was held in the Society room, No. 225 North Main Street, September 10th, at the usual hour, with President Moulthrop in the chair.

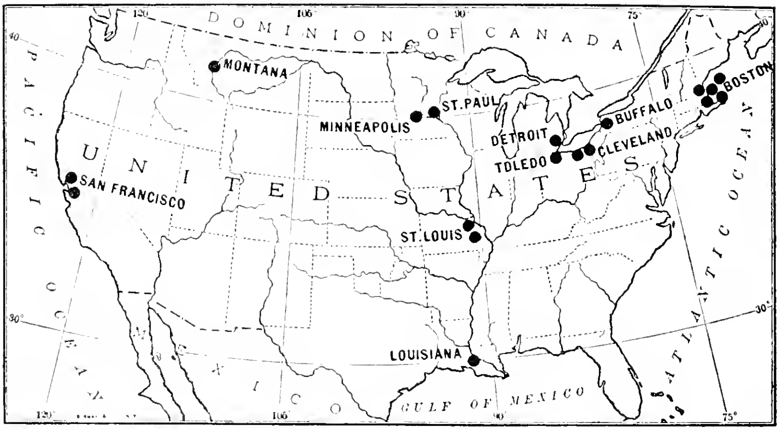
The minutes of the last meeting were read and approved.

The Secretary stated the desire of a member of the Society that the Mining Laws of the United States be made the subject for consideration at an early date, and it was voted to consider the same at the October meeting and that C. W. Goodale be requested to lead in the discussion.

The Chair appointed as a Committee to nominate officers for the coming year, Messrs. Goodale, A. N. Winchell and Word.

Messrs. A. N. Winchell and C. H. Bowman gave interesting talks on World's Fair topics and the industrial training department of Cornell University, after which the Society adjourned.

CLINTON H. MOORE, *Secretary.*



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

Association of Engineering Societies.

Vol. XXXIII. | DECEMBER, 1904. | No. 6.

PROCEEDINGS.

Engineers' Club of St. Louis.

587th Meeting, St. Louis, Mo., November 16, 1904.—The meeting was held at the Club rooms, 709 Pine Street, Wednesday evening, November 16th. In the absence of President Ockerson, Vice-President Moore presided.

There were present 45 members and 11 visitors.

The minutes of the 586th meeting were read and approved, and the minutes of the 376th meeting of the Executive Committee were read, as were also records of the reception to the members of the Iron and Steel Institute, held on November 4th, and the visit to the Mines Building with the members of the Iron and Steel Institute on November 6th.

A letter of thanks for the reception tendered the Iron and Steel Institute was received from Mr. H. A. Wheeler, Local Secretary of the American Institute of Mining Engineers, and read before the Club.

The application of Mr. Seth D. Merton for membership in the Club was presented, and referred to the Executive Committee for approval.

Mr. W. G. Brenneke, Chairman of the Committee on New Quarters, presented a final report of the Committee embodying the following statements:

"The Academy of Science proposes to lease to our Club for a period of five years two rooms on the second floor of their building (18 x 25 feet each) for the exclusive use of the Club, and in addition the use of the general assembly room on the first, second, third and fourth Wednesdays of each month; to furnish heat, light and janitor service and keep the quarters open to members at all times. Further, their Assistant Librarian will be in charge of the building during the day. The consideration to be five hundred ($500) dollars per annum.

"In the opinion of your committee, the last-named quarters are by far the most desirable of those examined, and they therefore recommend that the Engineers' Club close a lease with the Academy of Science for the quarters mentioned for the time and consideration stated."

Upon motion of Mr. R. S. Colnon, seconded by Mr. W. H. Bryan, the report of the Committee was accepted, and the proper officers instructed to draw up the proper lease with the Academy of Science for the quarters indicated.

Mr. Edward Flad, Chairman of the Committee on Amendments, presented a report of the Committee embodying certain amendments in the

Constitution and By-Laws, as indicated at the last meeting of the Club. After presenting the report Mr. Flad moved that the Constitution be amended as requested by the Committee, and that the amendments to the By-Laws be taken up in due form. After receiving a second, the proposed amendments were discussed at some length, and upon motion of Mr. H. H. Humphrey the matter was tabled, the vote standing 22 in favor, 19 against.

Mr. S. Bent Russell, Chairman of the World's Fair Committee, reported the proposed entertainment to the Western Society of Engineers of Chicago. The plan outlined by the Committee was to give a dinner to the members of the Western Society and ladies at the Tyrolean Alps, Friday evening, November 18th. Mr. W. G. Brenneke outlined a proposed trip of the Western Society to Thebes to inspect the new bridge over the Mississippi, and stated the arrangements that had been made through the courtesy of the Western Society to have the members of the St. Louis Engineers' Club, with ladies, participate in the trip.

The Secretary read the notice of the proposed dinner for the Western Society, which was to be mailed to members of the Club, and also read the following telegram, which was to be sent to Mr. Ralph Modjeski, of Chicago:

"Kindly extend cordial invitation of Engineers' Club of St. Louis to Western Society of Engineers and ladies to dinner at Tyrolean Alps, Friday evening."

The Secretary also stated that the plan for entertaining the Western Society, proposed by the World's Fair Committee, had been approved by the Executive Committee.

After a few preliminary remarks upon the work now being carried on at the U. S. Geological Survey Fuel Testing Plant, World's Fair Grounds, Mr. W. H. Bryan presented the following resolution:

"Resolved, That the Engineers' Club of St. Louis appreciates the work now under way at the Government Fuel Testing Plant at the Louisiana Purchase Exposition, and regrets the possibility that the unavoidably late start, the early closing of the Exposition, and the exhaustion of available funds, may bring the work to a close before the full measure of its usefulness has been realized.

"The Club heartily endorses the movement to continue the work after the close of the Exposition, and authorized the Executive Committee to present the matter in such manner as may seem appropriate to the owners of the apparatus, the Exposition authorities, our city officials, and the Congress of the United States, with a view of retaining the use of the plant, and site, and of securing funds to continue the work."

The above resolution was approved by the Club.

The Nominating Committee, appointed at the last meeting, presented the following report:

"Your Committee for nomination of candidates for officers of the Club for the ensuing year submits the following names:

For President—Mr. Robert Moore.

For Vice-President—Mr. W. A. Layman.

For Secretary—Mr. R. H. Fernald.

For Treasurer—Mr. E. E. Wall.

For Librarian—Mr. E. B. Fay.

For Directors—Mr. A. P. Greensfelder and Mr. H. H. Humphrey.

For Members of the Board of Managers of the Association of Engineering Societies—Mr. Hans C. Toensfeldt and Mr. C. A. Moreno."

Mr. E. B. Fay, after presenting the many difficulties encountered in moving to new quarters, moved that the Committee on New Quarters be continued and be instructed to look after the moving of the Club to its new quarters. Motion was carried.

Upon motion of Mr. Edward Flad the Chair was authorized to appoint a committee to make the necessary arrangements for the annual dinner of the Club. The Chair appointed the present World's Fair Committee to look after this matter.

The paper of the evening, by Capt. C. H. Smith of the Westinghouse Company, upon the Westinghouse-Parsons' Steam Turbine, was received with marked attention and was discussed by Messrs. Bryan, Langsdorf, Fish, Humphrey, Laird, Russell, Moore, McCulloch, Capt. Smith, and others.

Upon motion of Professor Langsdorf a vote of thanks was tendered Capt. Smith for his paper of the evening.

Adjourned. R. H. Fernald, *Secretary*.

St. Louis, Mo., November 18, 1904.—On the evening of November 18th the Engineers' Club of St. Louis entertained the Western Society of Engineers of Chicago, and their ladies, at dinner at the Tyrolean Alps, World's Fair Grounds. There were 106 members of the Western Society, including the ladies, and between 30 and 40 members of the Engineers' Club, and ladies, present.

Immediately after the dinner mentioned above the company adjourned to the Union Station, where the train was taken for Thebes, Ill., to inspect the bridge across the Mississippi at that point. About 100 members of the Western Society of Engineers, and ladies, together with 32 members of the Engineers' Club and 26 guests, made the trip. The party arrived at Thebes during the night. After breakfast at the Construction Plant the party visited and inspected the east end of the bridge. The river was then crossed for an inspection of the concrete arches and west approach to the bridge, after which a trip was made to the railroad yards. After luncheon, at 12.30, the party returned to St. Louis, leaving Thebes about 1.30 o'clock.

R. H. Fernald, *Secretary*.

The Civil Engineers' Club of Cleveland.

Cleveland, December 13, 1904.—The regular December meeting of the Club was held in the Electricity Building of the Case School of Applied Science, and was called to order by Dr. D. C. Miller, Vice-President, at 8.30 P.M. Present, forty-one members and visitors.

The tellers, Messrs. C. O. Palmer and W. C. Clark, reported the election to active membership of the following: W. Orien Brosius, John P. Dowd, C. E., Andrew B. Lea and S. G. Werner.

The following applications for active membership, approved by the Executive Board, were read: H. S. Johannsen, J. R. Poe, B.S., and Arthur E. Spooner, C. E.

The Secretary read a communication from the Secretary of the American

Society of Civil Engineers, announcing the decision of the Society to hold its next annual convention in Cleveland during the last week in June, 1905.

The paper of the evening, "The Use of the Engineering Laboratory in Education," was read by Professor Benjamin, who afterward illustrated his subject by showing to the Club the new power laboratory of the school with its various machinery and apparatus in operation.

Lunch was served in the laboratory.

JOE C. BEARDSLEY, *Secretary.*